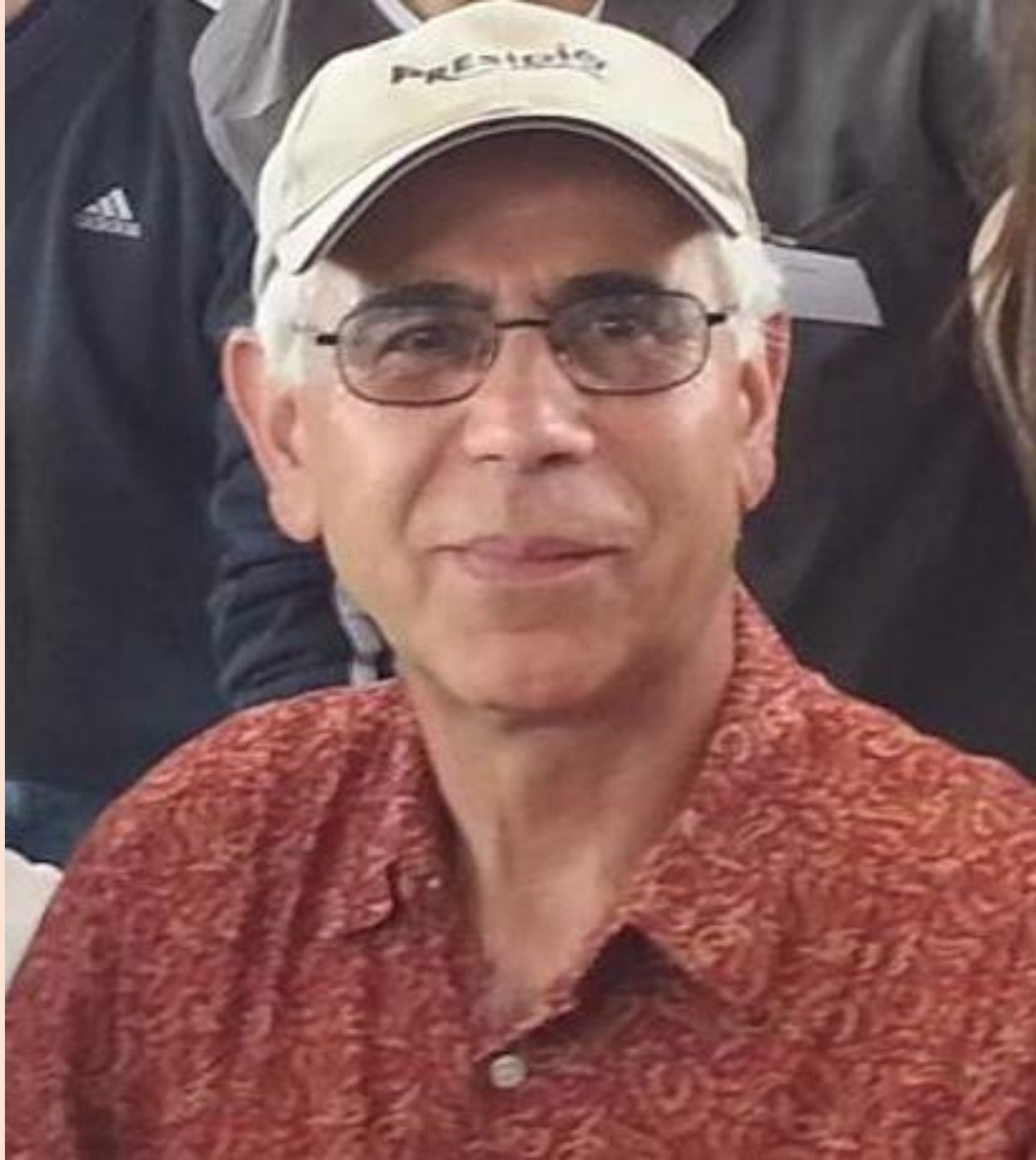
Dr. Themis Michailides, University of California, Davis, plant pathologist based at the Kearney Agricultural Research and Extension Center in Parlier.



Botryosphaeria Panicle and Shoot Blight of Pistachio

Themis J. Michailides
University of California Davis - Kearney Agricultural Research and Extension Center

Diseases affected by wet weather

1. PISTACHIO: Botryosphaeria panicle and shoot blight

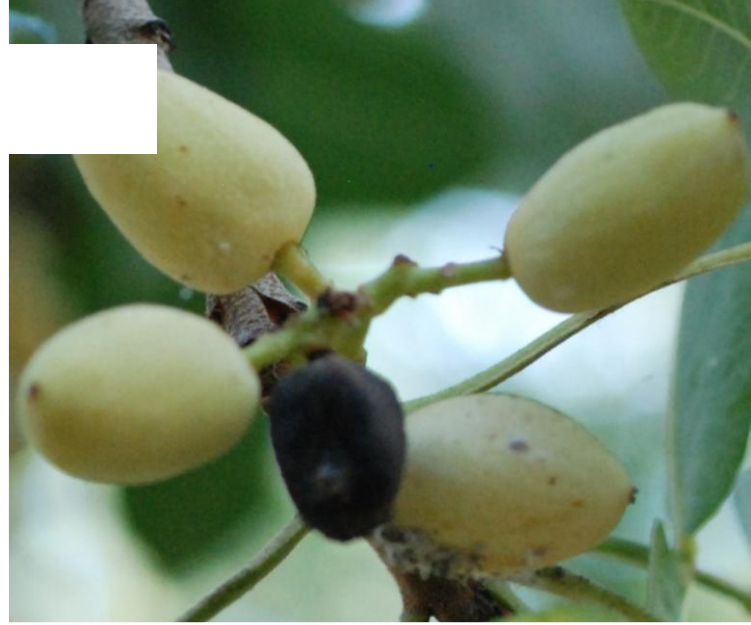
2. Anthracnose of pistachio in California

Annual rainfall in inches for period 1979 to 2023 in California

Season (July 1-June 30)	Total Inches of Rainfall	Inches Above (+) Overall Season Average*
1979-1980	21.02	+ 9.16
1982-1983	25.61	+ 13.75 ***
1992-1993	23.66	+ 11.86
1994-1995	22.80	+ 10.99
1997-1998	31.28	+ 19.42 ***
2004-2005	26.51	+ 14.65
2022-2023	24.12	+ 12.26

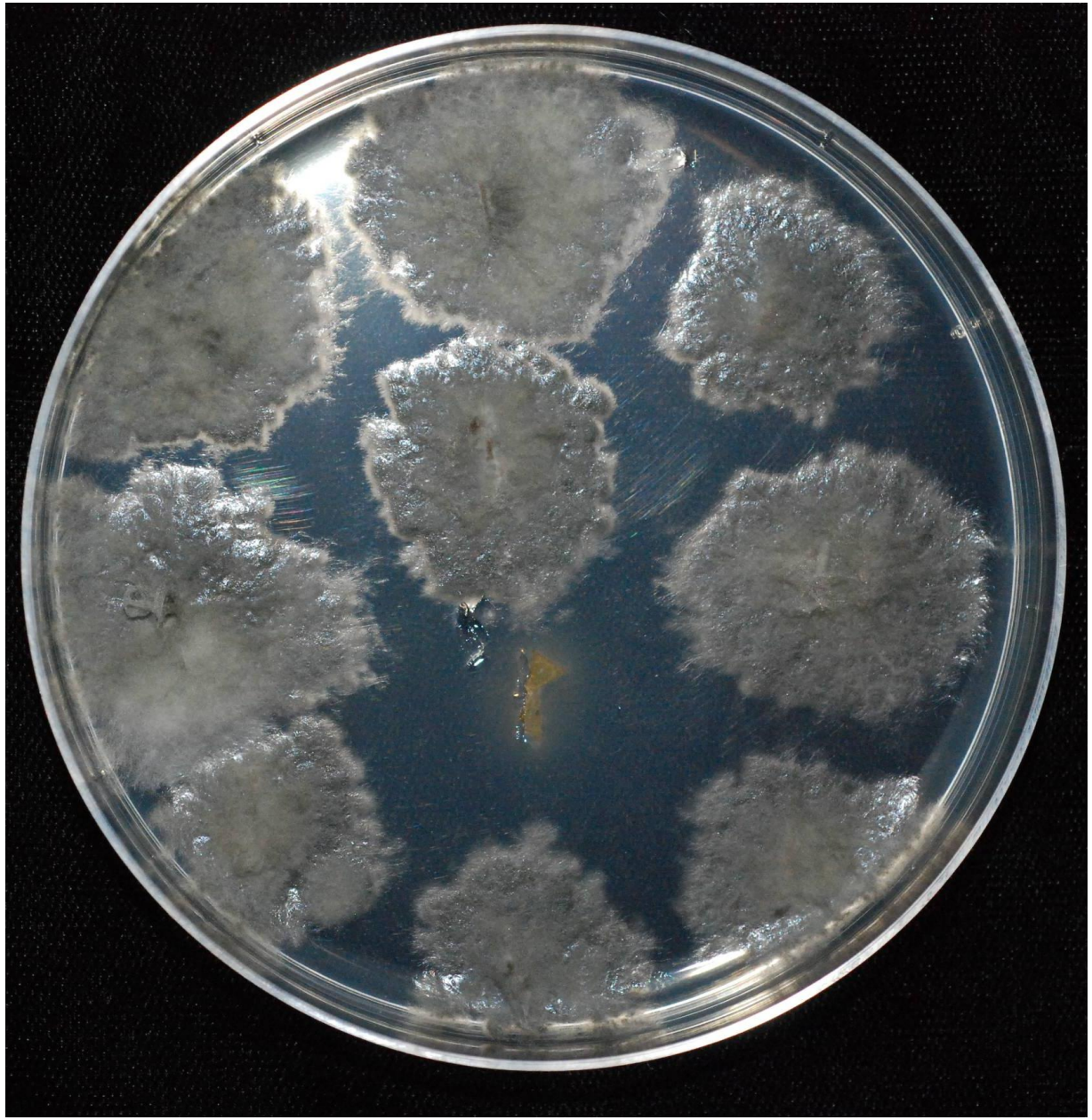
1. Botryosphaeria panicle and shoot blight

Discovered in 1984



Pistachio Acreage in 1984: 45,000 Acres

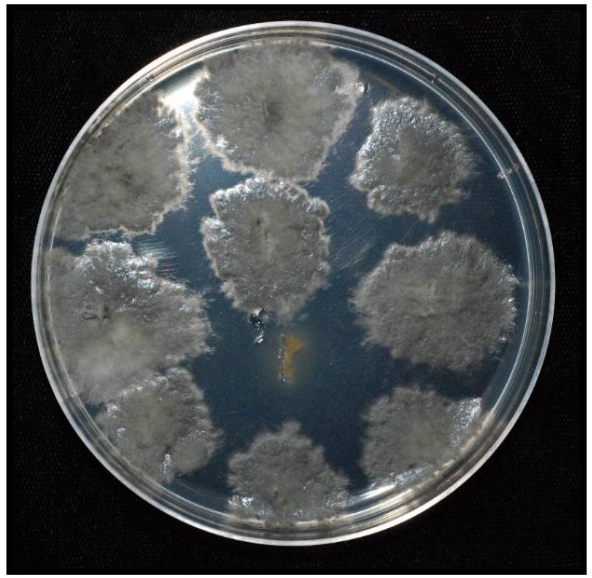
The first article: 1985



Botryosphaeria dothidea

Summary of Botryosphaeriaceae in nut crops – California

Fungal species	Walnut	Pistachio	Almond
Botryosphaeria dothidea	+	+	+
Neofusicoccum parvum	+	+	+
Neofusicoccum mediterraneum	+	+	+
Diplodia mutila	+	---	---
Neofusicoccum nonquaesitum	+	---	+
Neofusicoccum vitifusiforme	+	+	---
Diplodia seriata	+	+	+
Dothiorella iberica	+	+	+
Lasiodiplodia citricola	+	+	+
*Neoscytalidium dimitiatum**** (=*Hendersonula toruloidea*)	+	+	+



Historical background

During 1984-1988, the pistachio industry believed that Bot was not of a major concern to them.

Opinions that only a few growers in northern California were affected…plus there was not much pistachio acreage there.

Thus, the industry funding was reduced and eventually discontinued in 1988.

However, in 1988, 3 more orchards in Central Valley of California found with severe Botryosphaeria … and a few years later, more orchards in Central and Southern CA.

Annual rainfall in inches for period 1979 to 2023 in California

Season (July 1-June 30)	Total Inches of Rainfall	Inches Above (+) Overall Season Average*
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1997-1998	31.28	+ 19.42 ***
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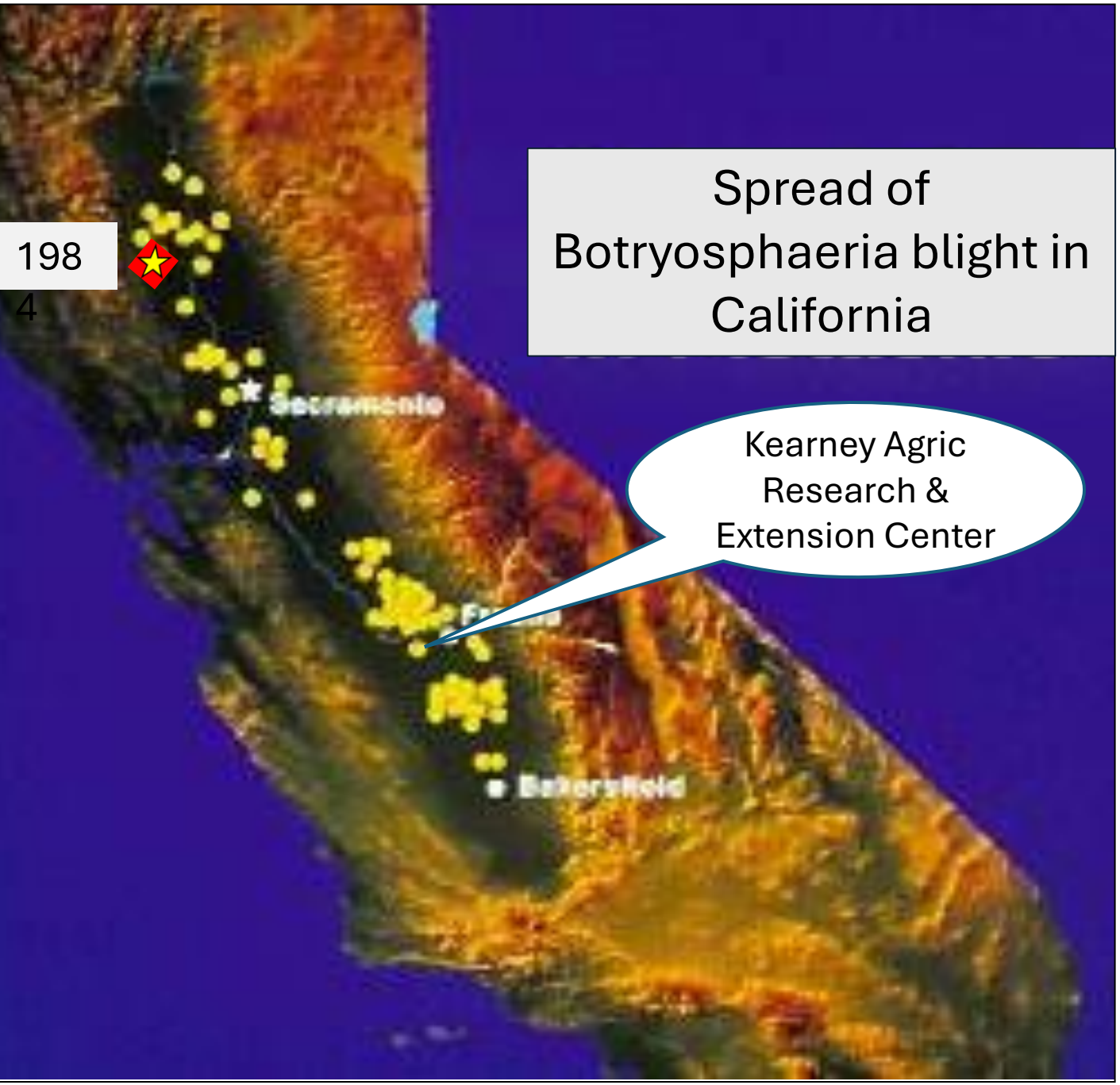
2022-2023	24.12	+ 12.26

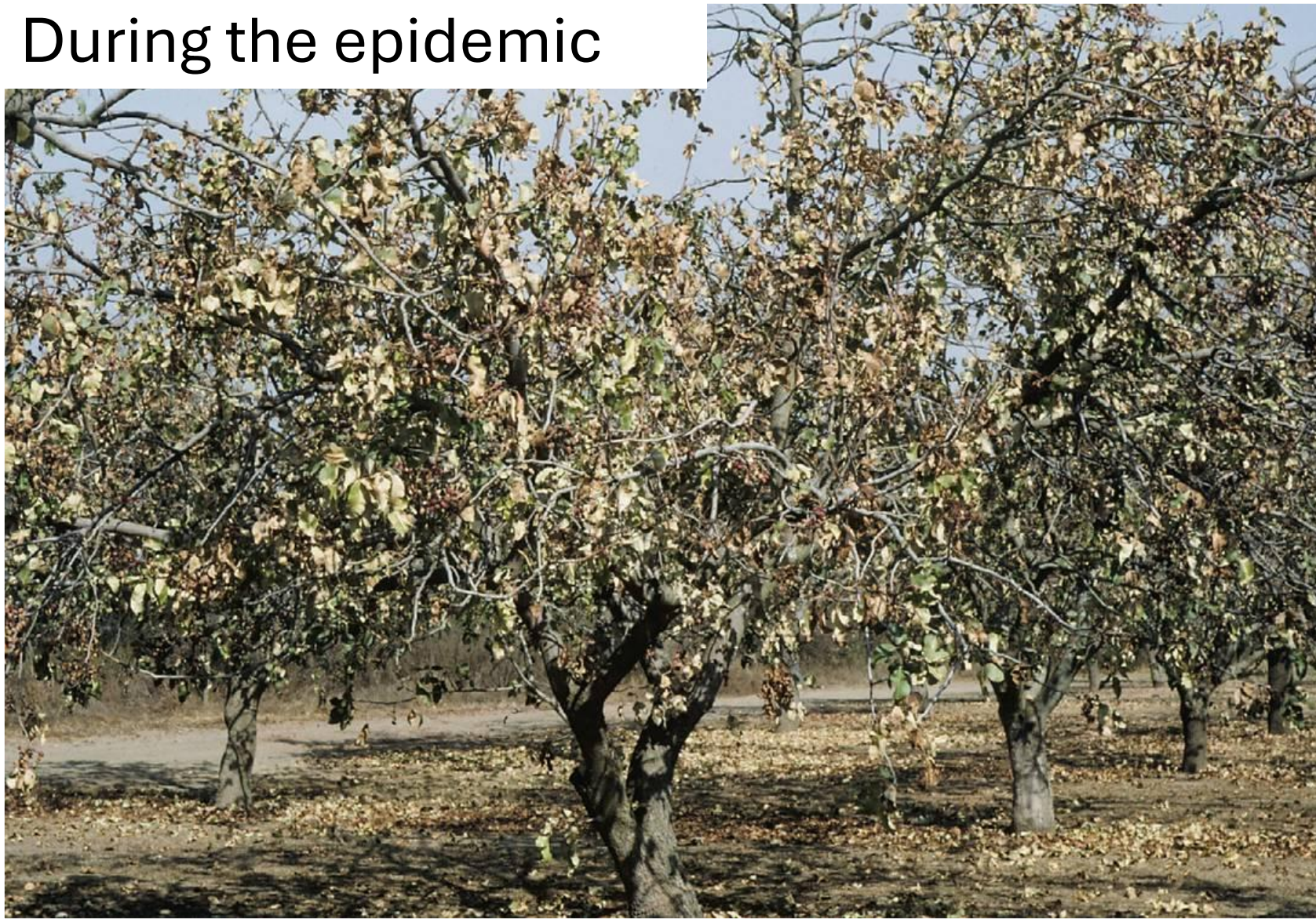
Normal average: 12-13 inches.



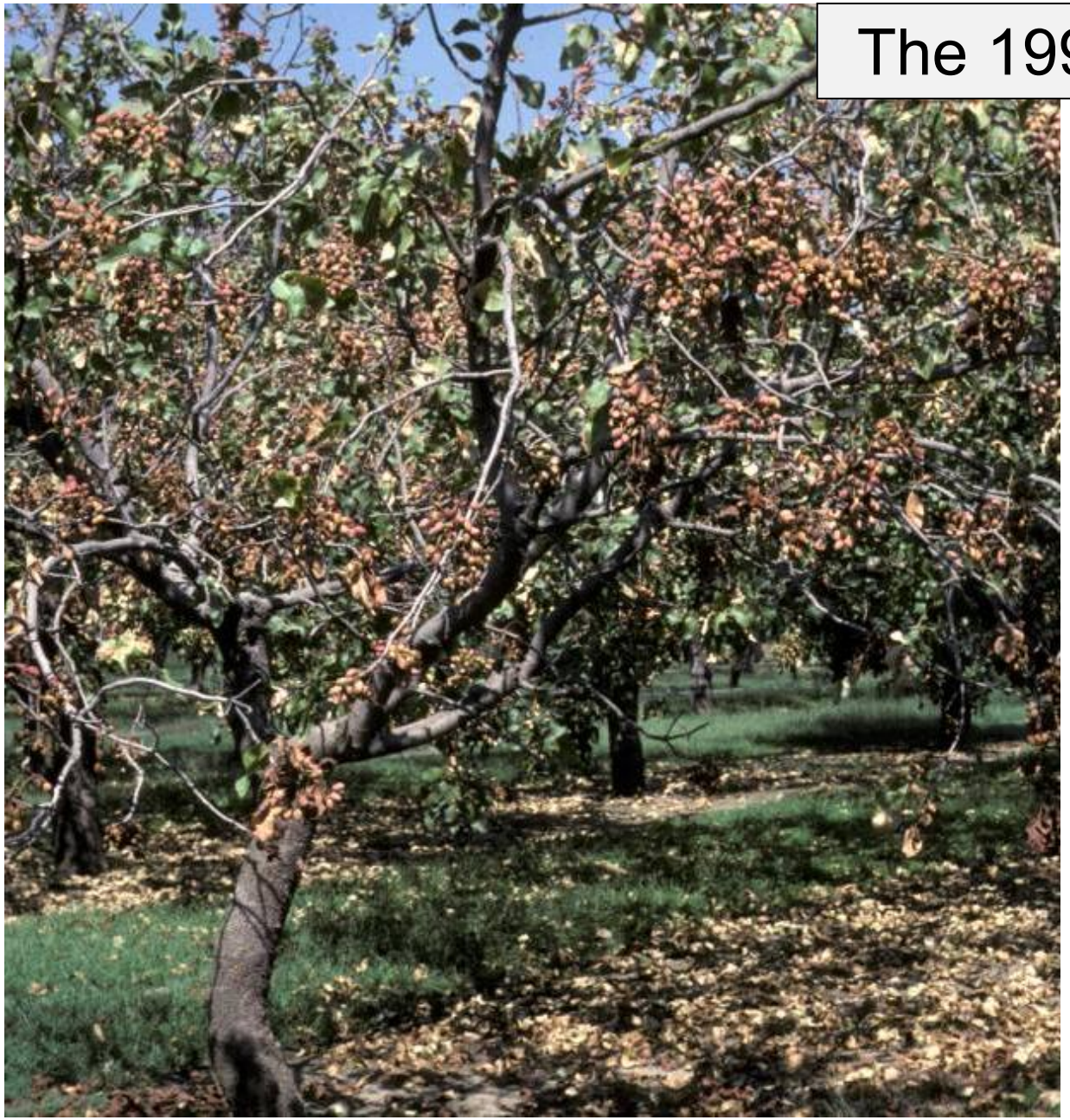
Emergency situation…

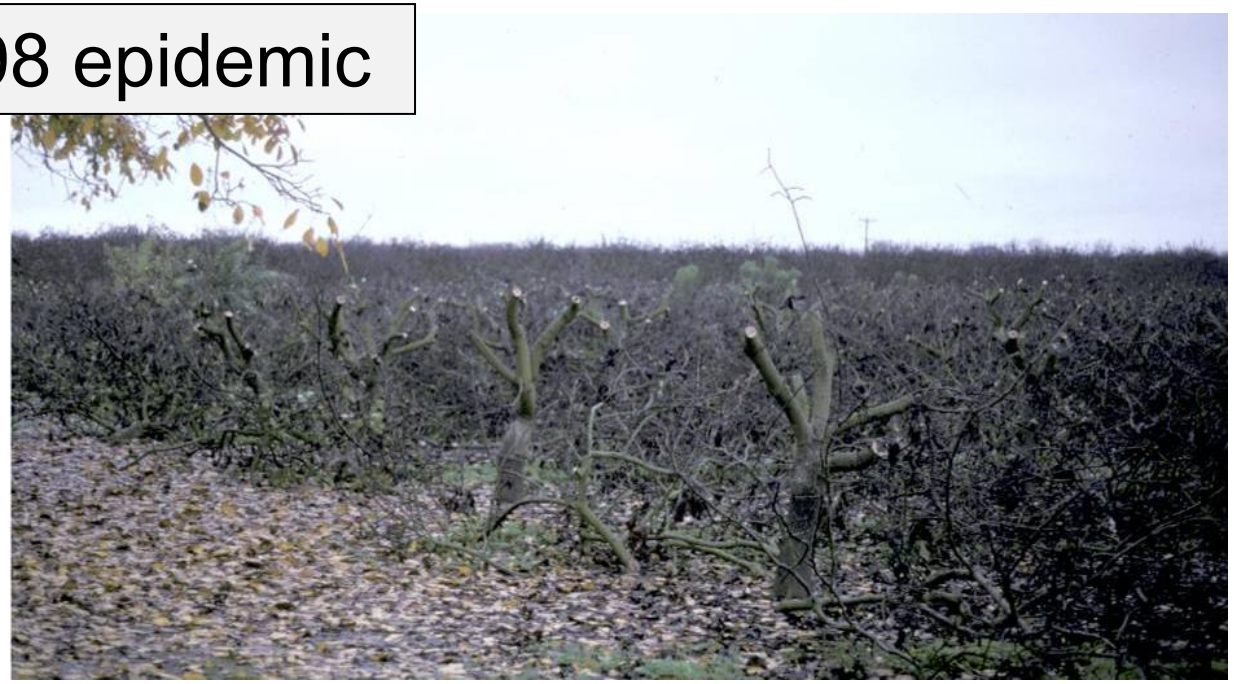
- **The industry was alerted during 1995 - 1996…**
- *** A major Botryosphaeria epidemic in 1998 & 1999***
- The industry made major efforts by creating the Botryosphaeria Working Group…
- Research funds $1,000,000+ were raised by the growers for research on Botryosphaeria panicle and shoot blight…

During the epidemic



The 1998 epidemic





Botryosphaeria panicle and shoot blight

Under conducing conditions, the first blighted structures are the blighted leaves from infections at the base of the petiole.

leaf wilting, and the blight of the entire shoot.

These shoots retain their killed leaves that will turn a bright brown color, very distinct among the green, healthy foliage. In years with severe disease, multiple blighted shoots can develop per tree.

Botryosphaeria panicle and shoot blight

The most devastating blight phase of the disease is the killing of the fruit clusters (panicle blight).

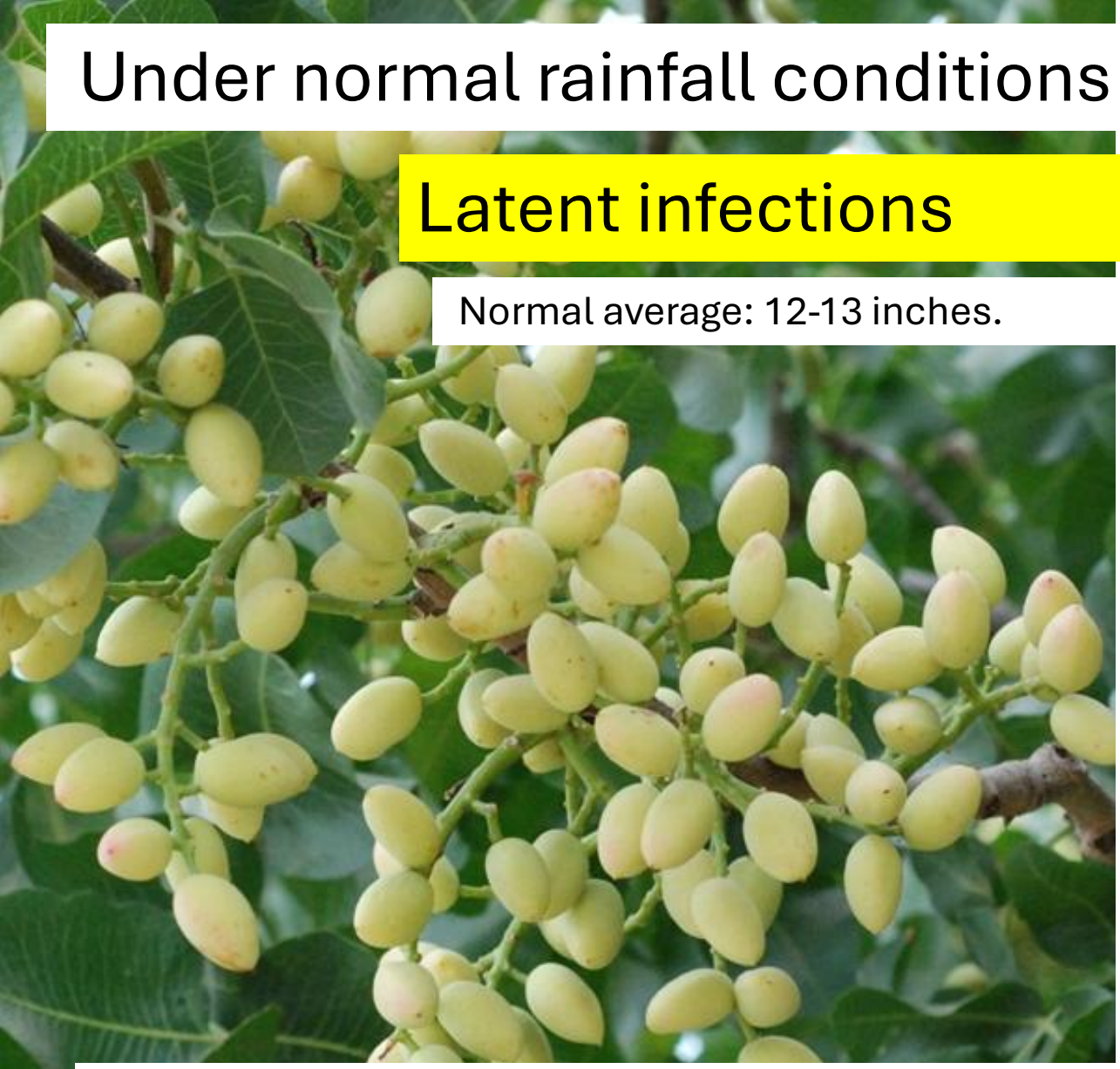
Infection of bud or latent infection of the fruit.

Girdling of the cluster since the infection will develop at the rachis base, and it is usually very quick (1 week).

Under normal rainfall conditions

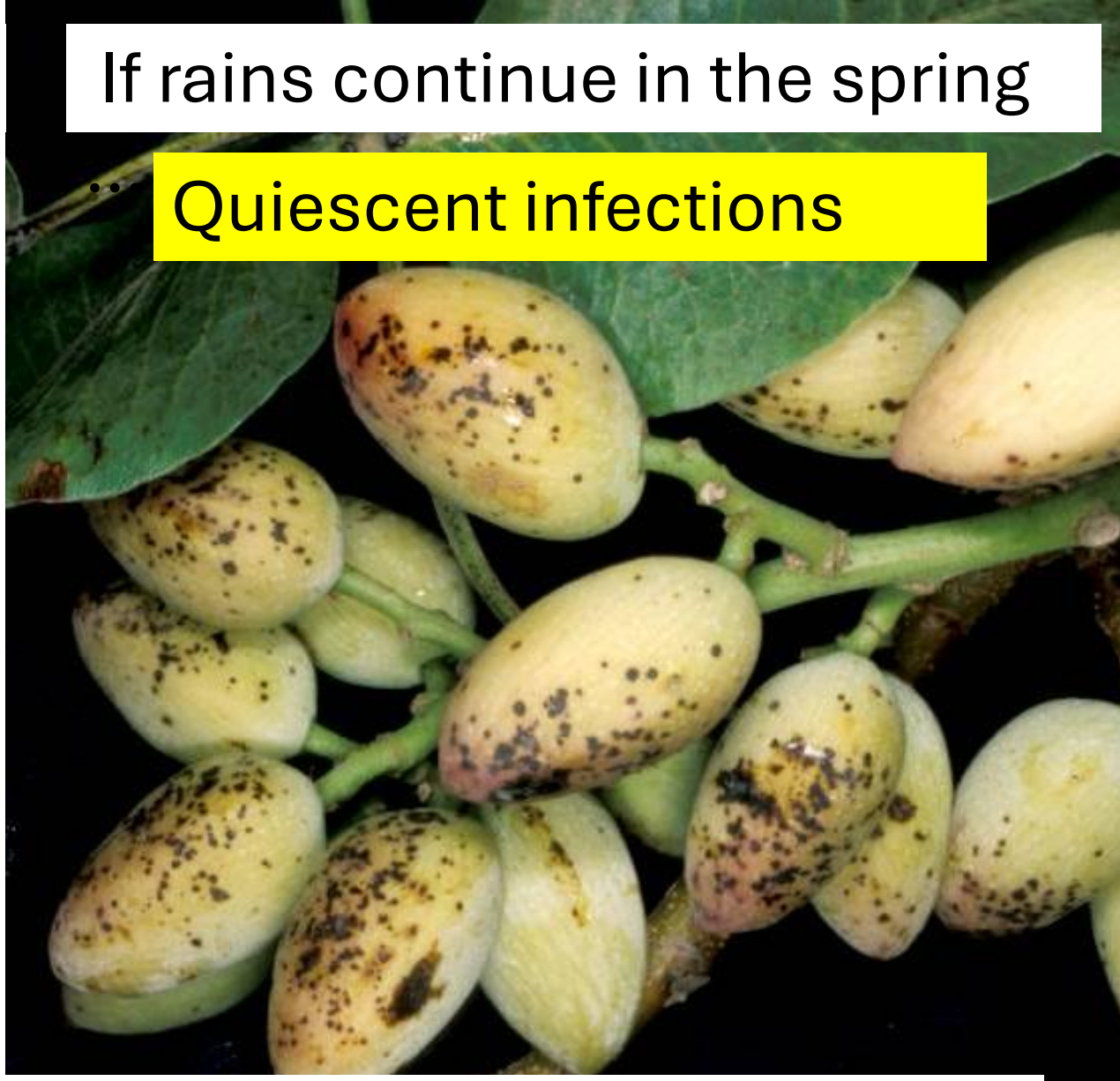
Latent infections

Normal average: 12-13 inches.



If rains continue in the spring

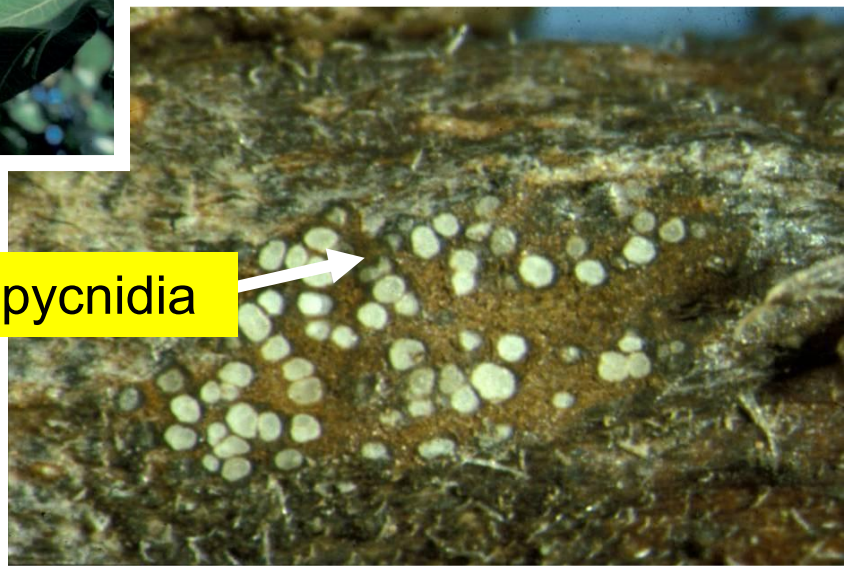
Quiescent infections



Fruit latent infections will develop during summer and blight the fruit. The infection will move from the fruit into the rachis to kill either part of the cluster or the entire cluster

After reaching the base of the rachis, the infection will move into the last year's shoot to cause a distinct canker.

canker initiated from infected male flower

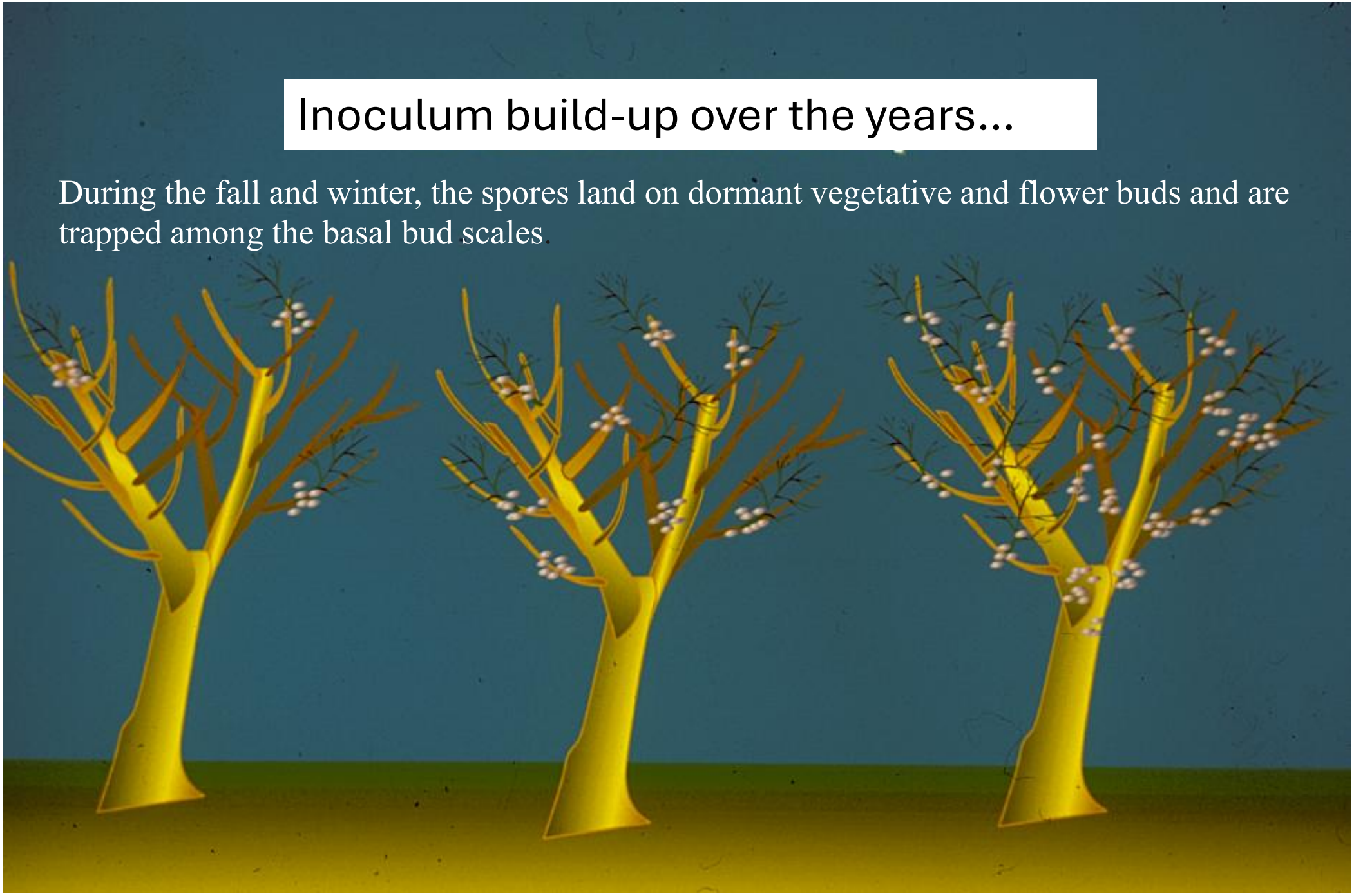


blighted shoot showing pycnidia (the spore-producing structures of the pathogen).

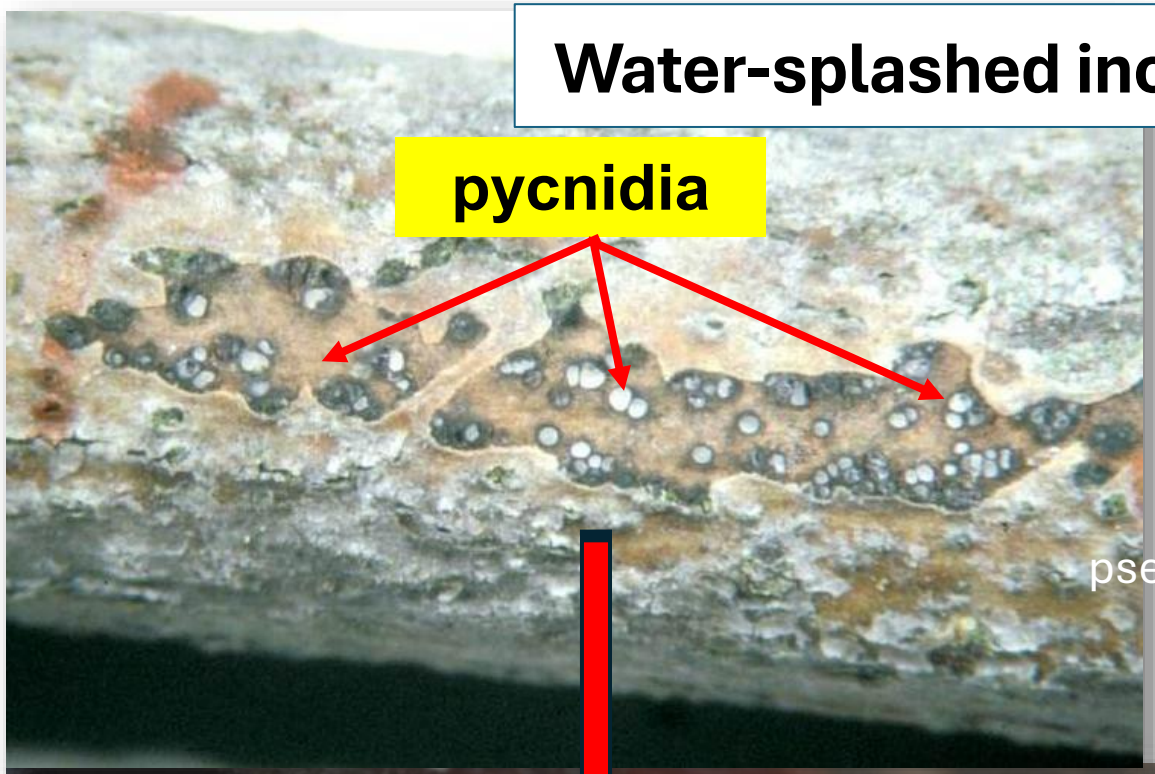
Botryosphaeria-infected parts are retained on the trees

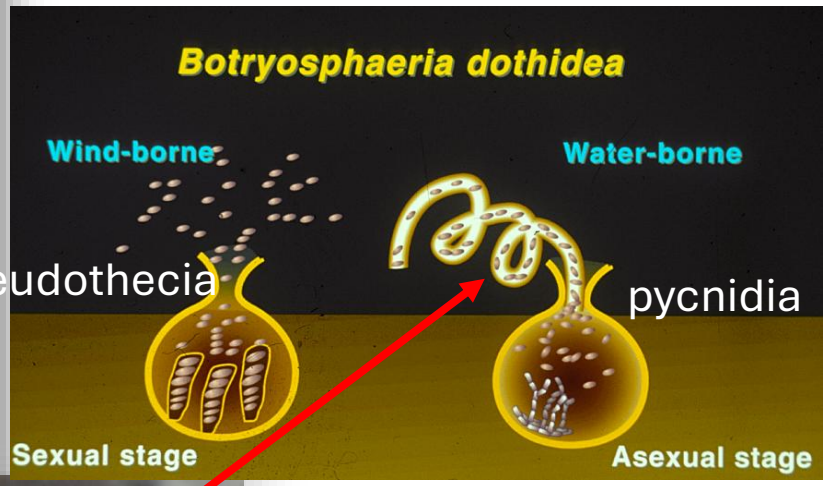
Inoculum build-up over the years…

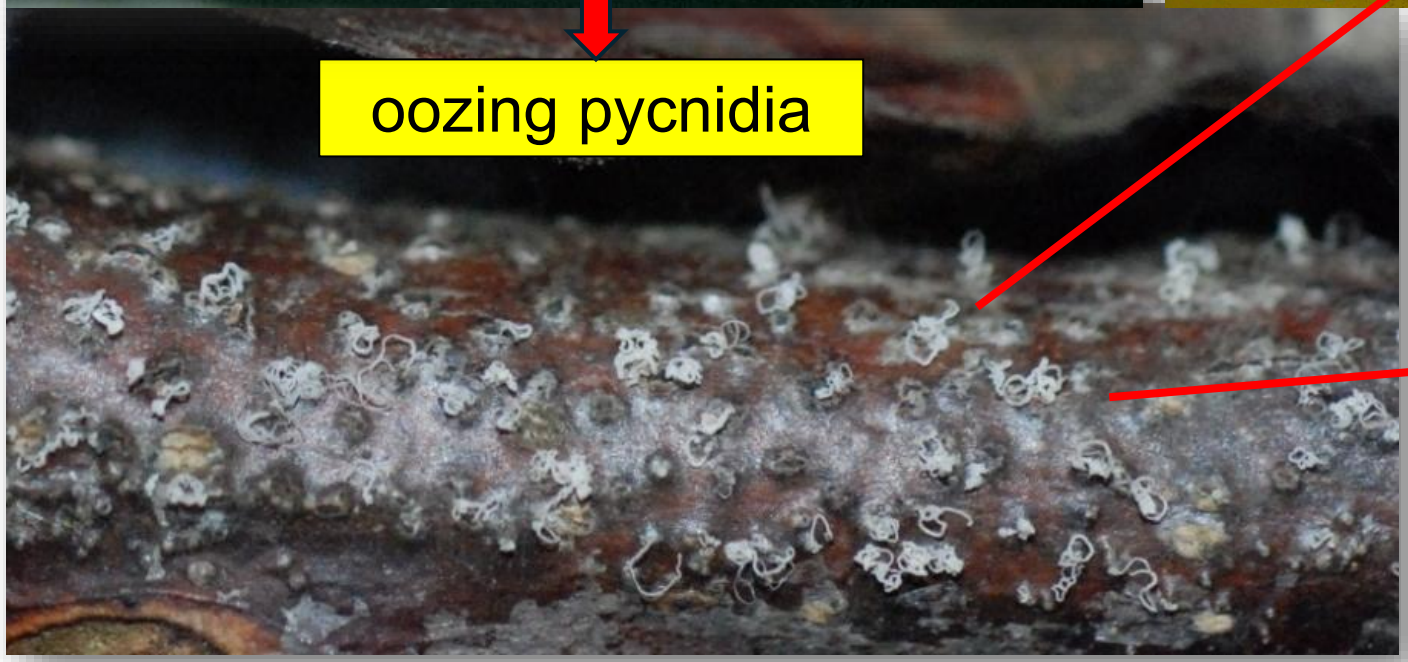
During the fall and winter, the spores land on dormant vegetative and flower buds and are trapped among the basal bud scales.

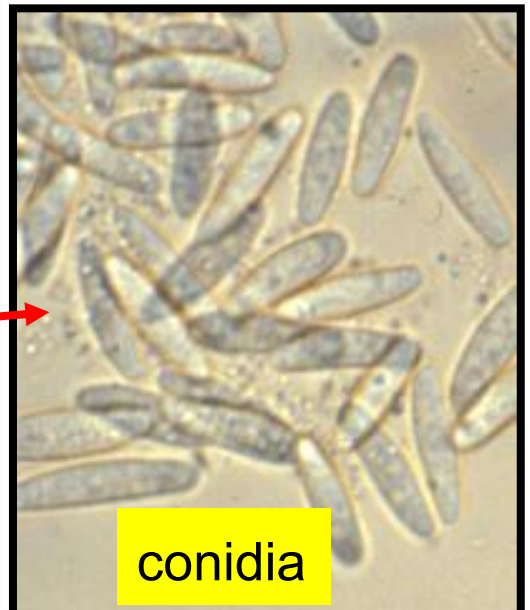


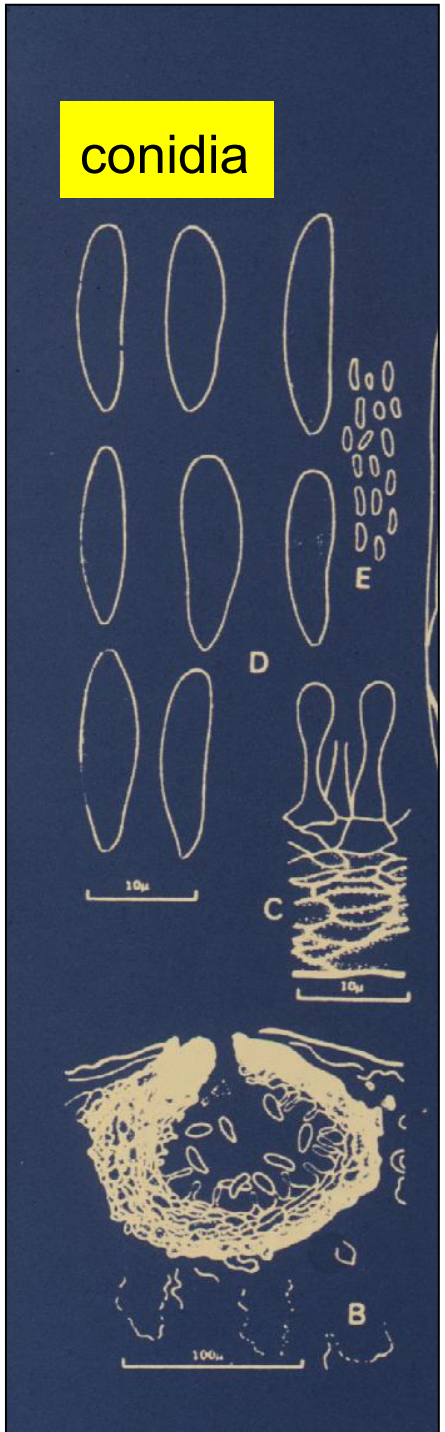
Water-splashed inoculum from pycnidia





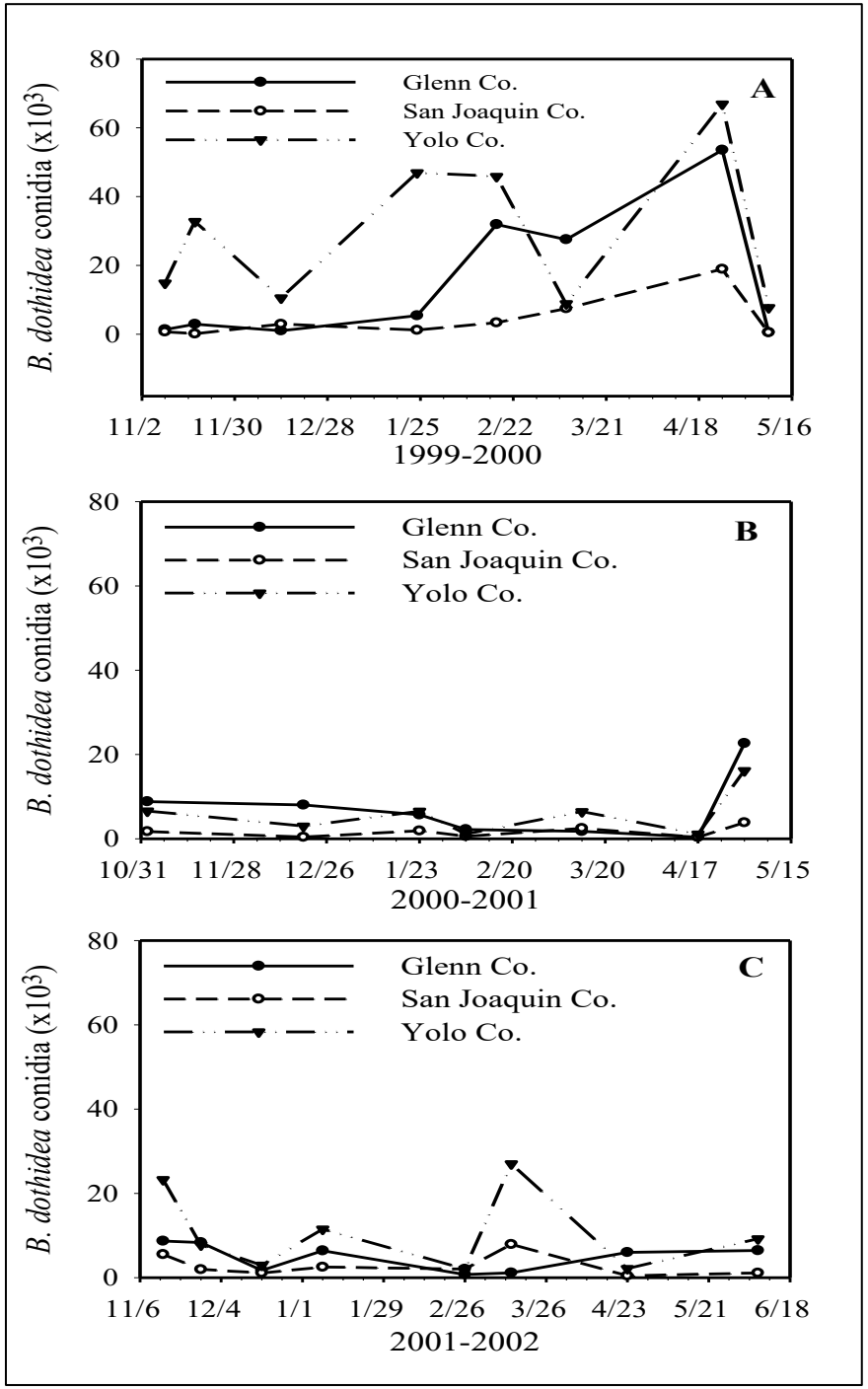






Spread of Botryosphaeria spores with rainwater

Levels of Botryosphaeria conidia collected in three pistachio orchards during rain events

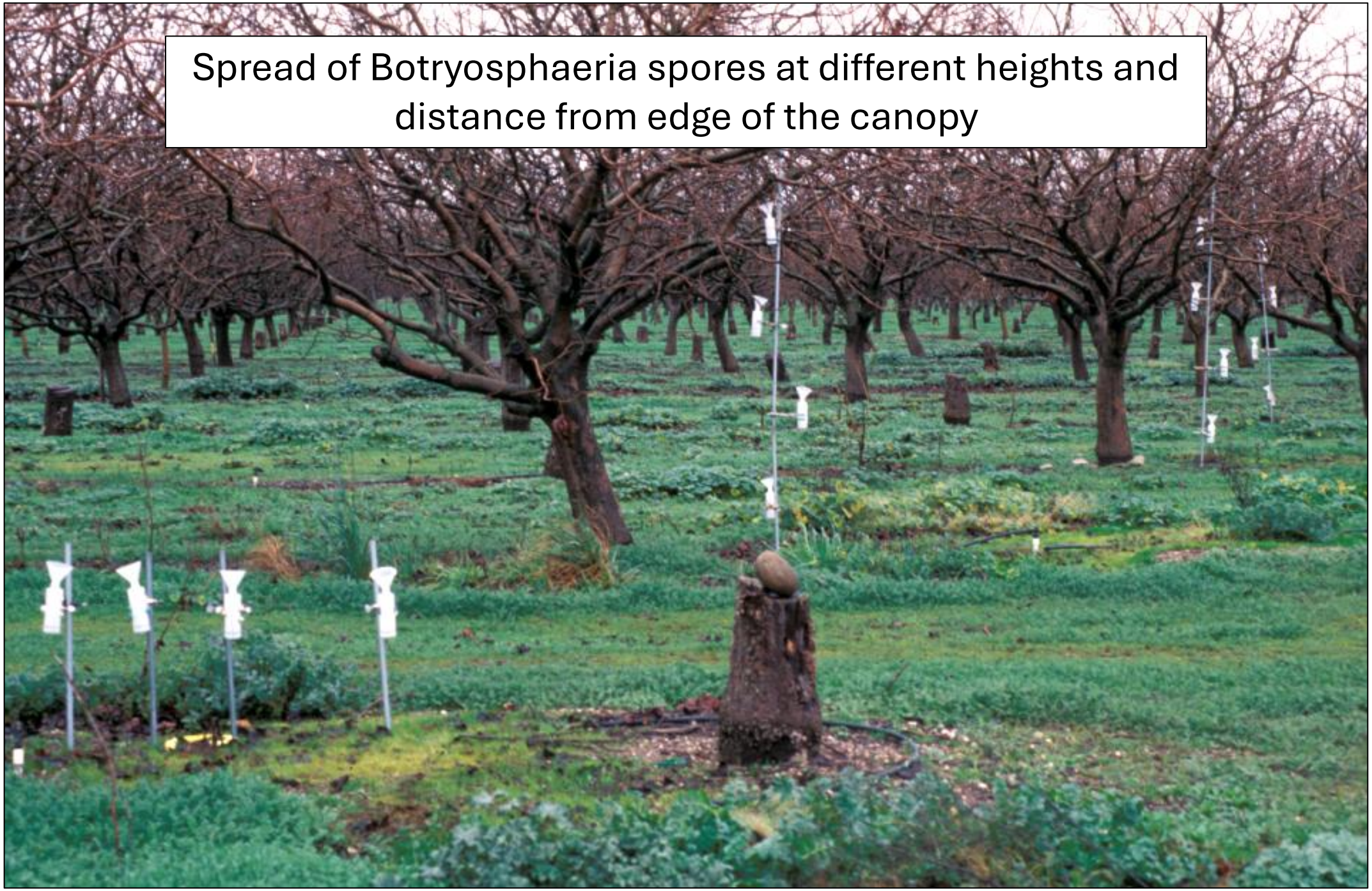


The orchards have higher risk for disease in this year.

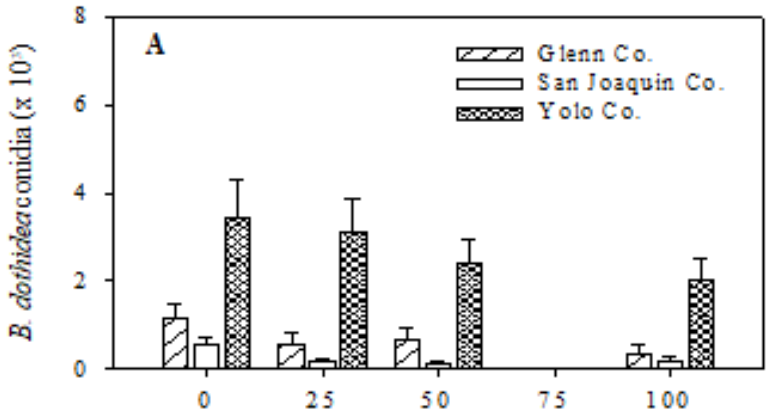
Year 1

Year 2

Year 3

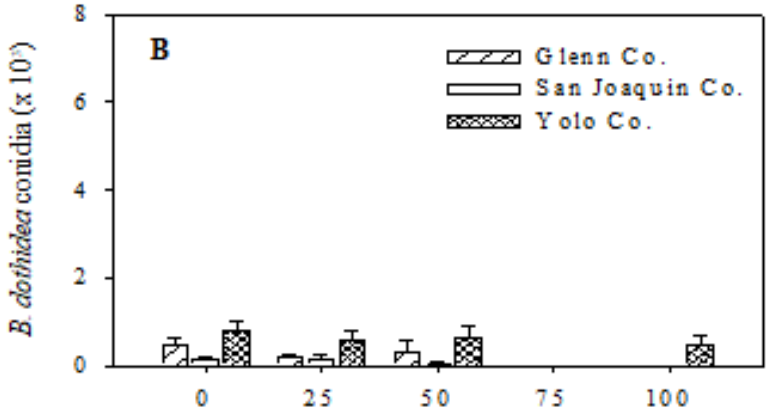

Spread of Botryosphaeria spores at different heights and distance from edge of the canopy

Number of *Botryosphaeria dothidea* conidia collected in rainwater at four distances outside tree canopy of pistachio trees in three commercial orchards

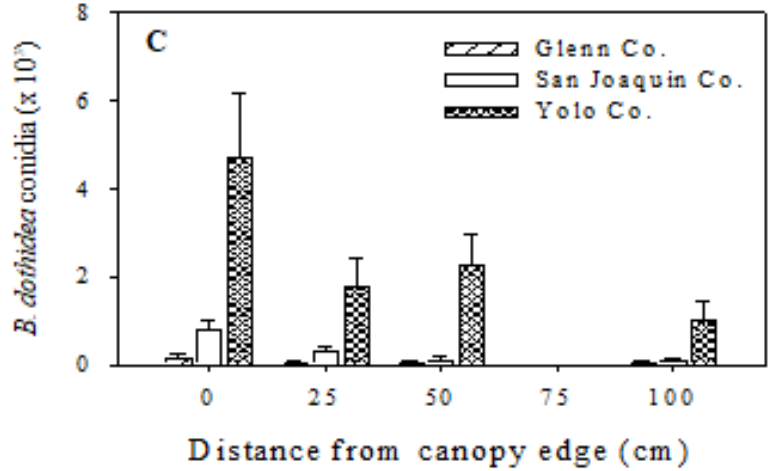


In the 1st & 3rd years, the orchard in Yolo Co. has higher risk for disease spread.

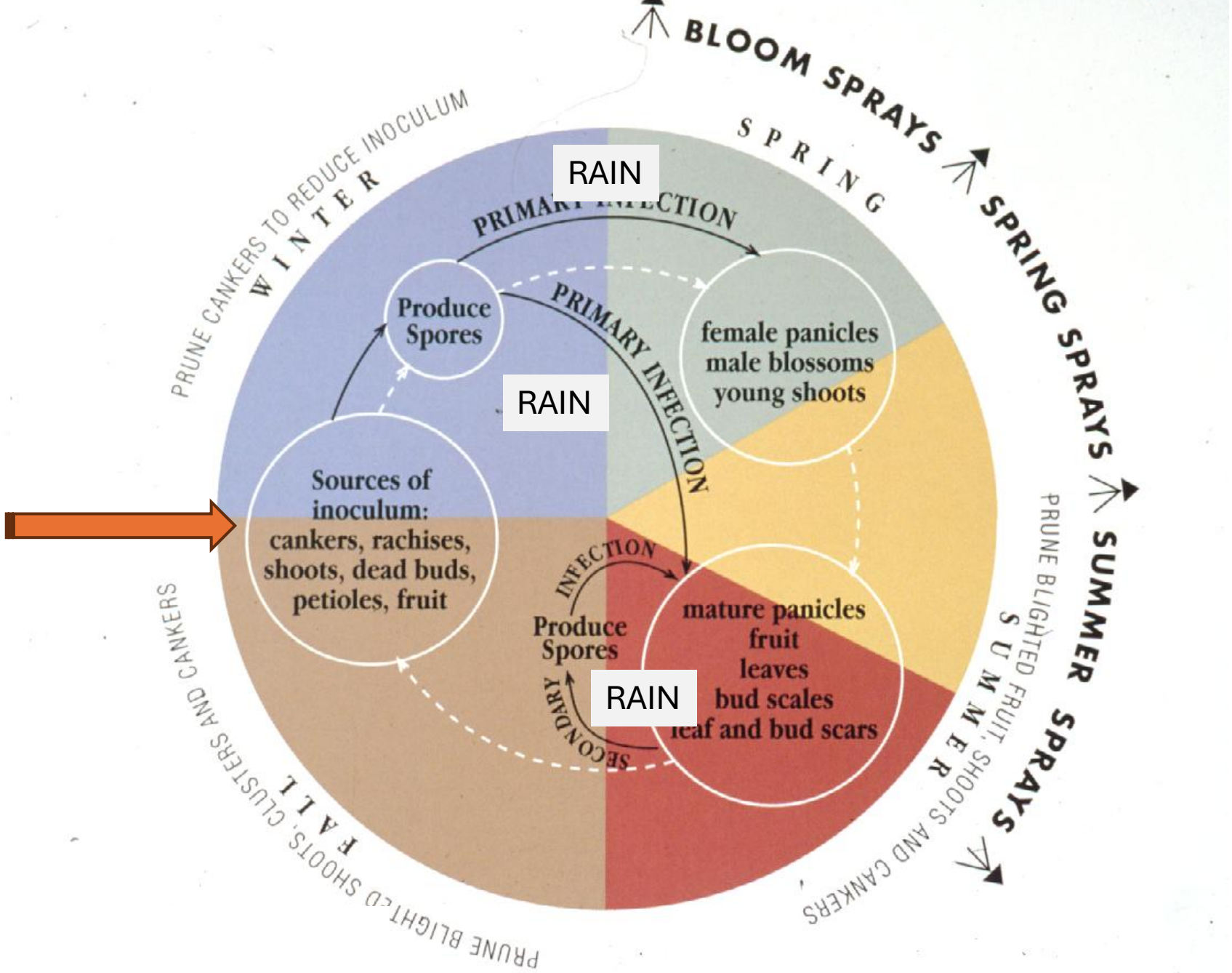
Year 1



Year 2

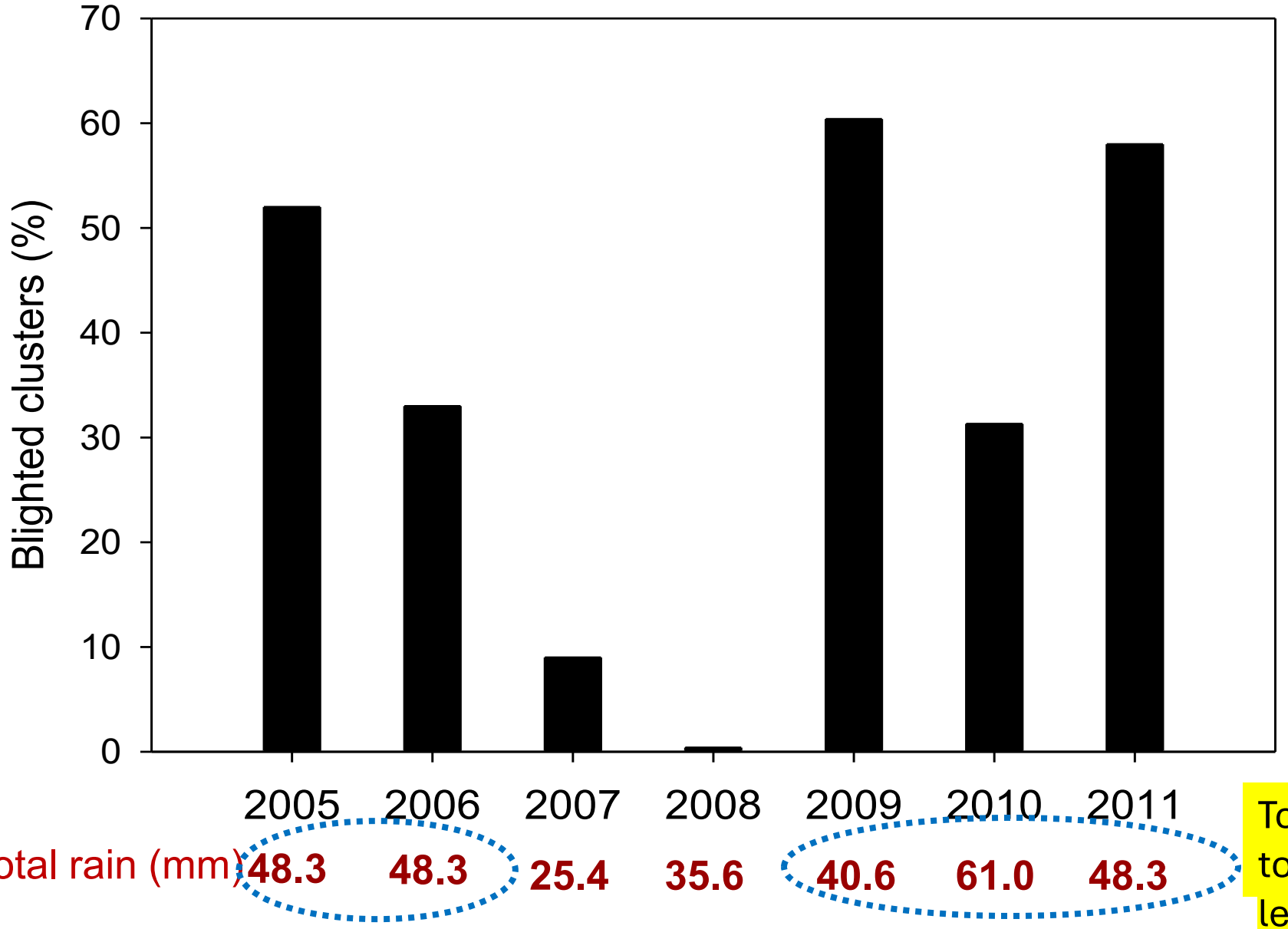


Year 3



DISEASE CYCLE OF BOTRYOSPHAERIA PANICLE AND SHOOT BLIGHT OF PISTACHIO

Botryosphaeria blight in unsprayed trees (Glenn County, California)



Conditions for infection events:

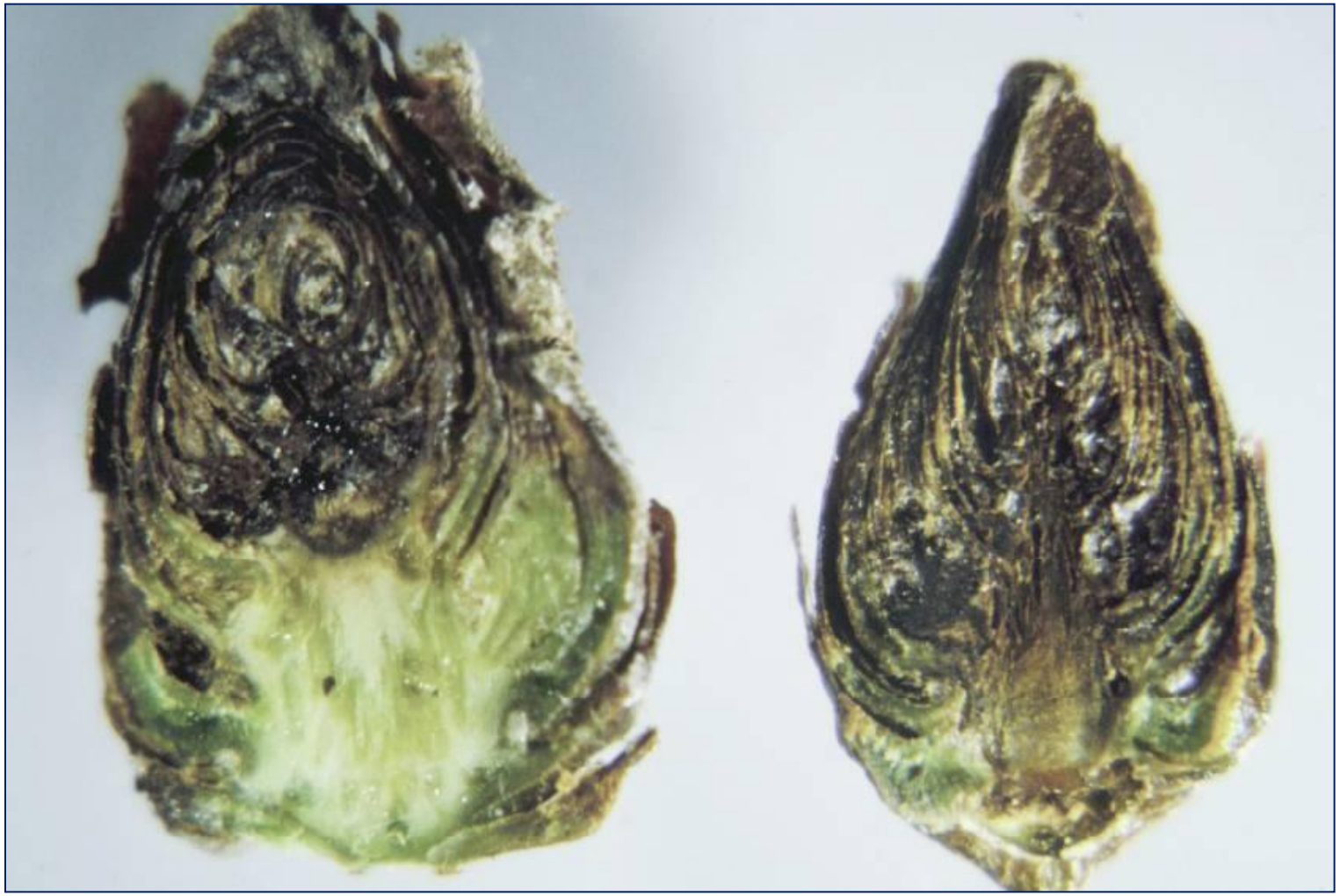
- ✓ At least 5 mm of rain
- ✓ At least 10 °C

Optimal Temperatures:

- ✓ Spore germination: 17-36 °C
- ✓ Growth: 27-30 °C
- ✓ Dis develop. : 27- 33 °C
- ✓ Pycnidia formation: 27 °C

Total rain above 40 mm during Dec to April triggered severe disease levels

The disease also kills buds (summer/fall)

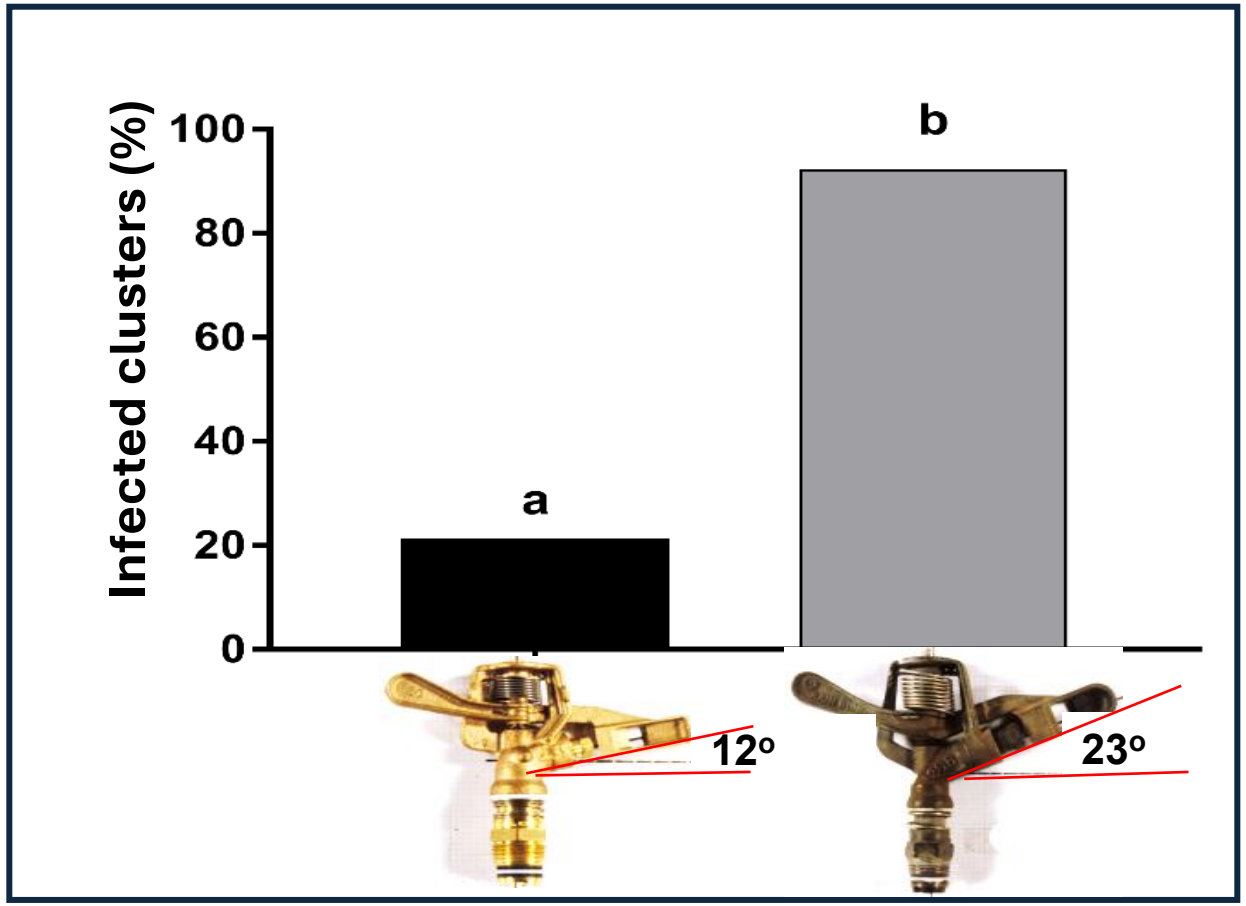


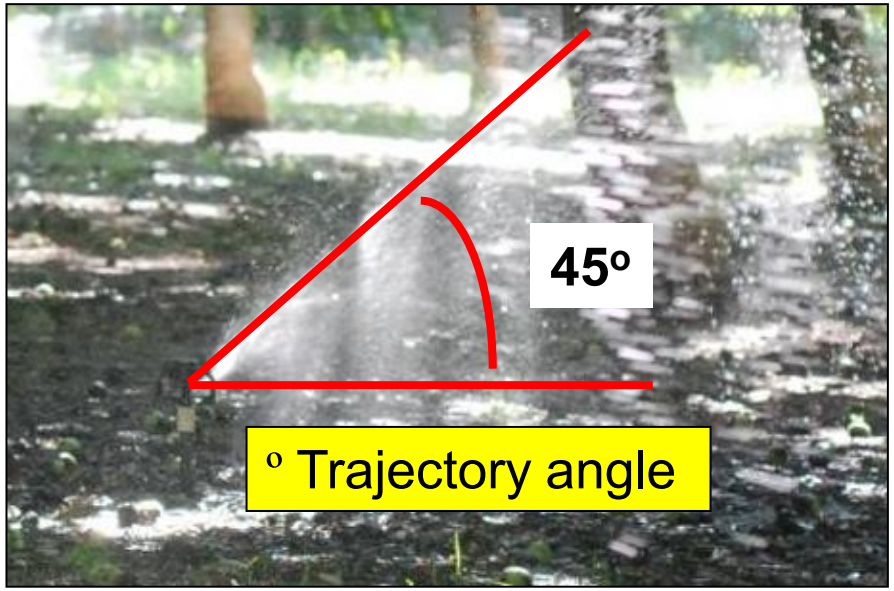
Disease Management

A. Cultural Control

1. **Irrigation management**

12º ⟵ **23º**





A. Cultural Control

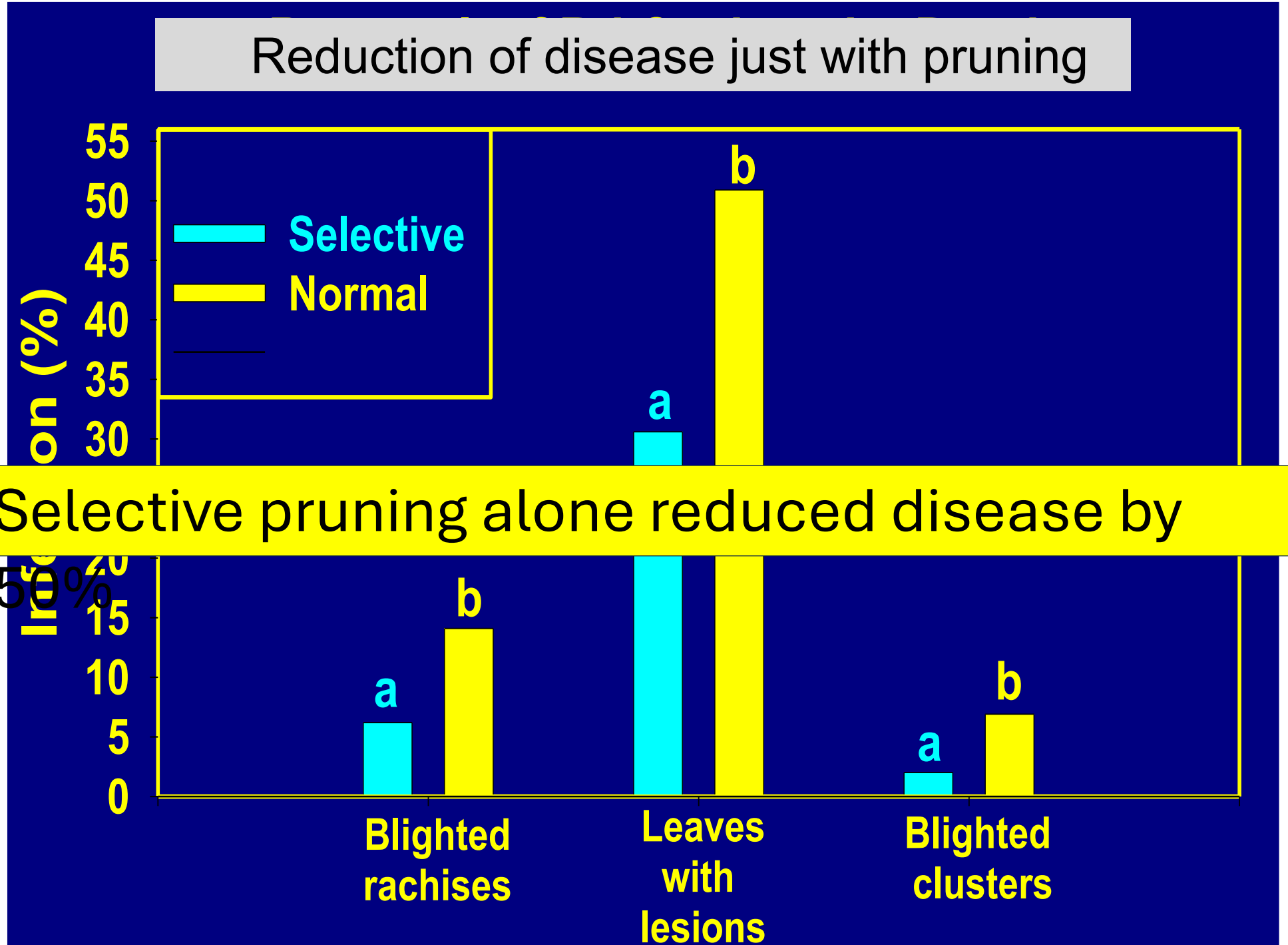
2. Sanitation:

a) Winter pruning
b) Summer pruning

b) Summer pruning

Burning of infected prunings outside the orchard

Reduction of disease just with pruning



Selective pruning alone reduced disease by

50%

Strobilurins (FRAC 11)
Abound (azoxystrobin)
Gem (trifloxystrobin)
Cabrio (pyraclostrobin)

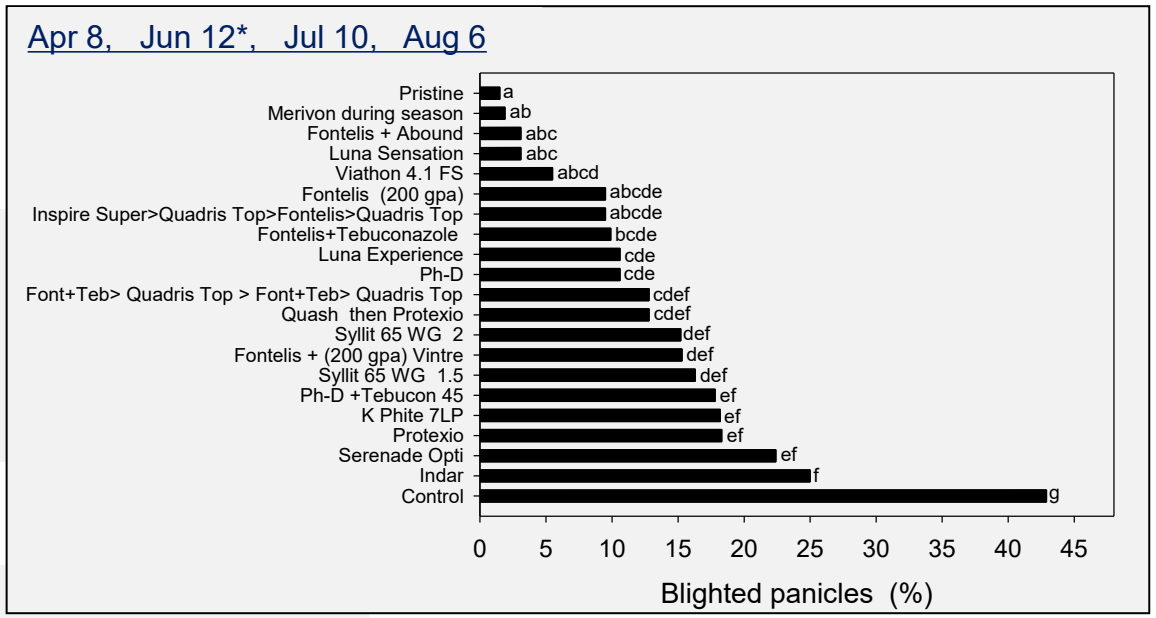
SDHI (FRAC 7)
Endura (boscalid)
Luna Privilege (fluopyram)
Fontelis (penthiopyrad)

Premixtures
Pristine [SDHI (7)/QoI (11)]
Merivon [SDHI (7)/QoI (11)]
Luna Sensation [SDHI (7)/QoI (11)]
Luna Experience [DMI-triazole (3)/SDHI (7)]
Inspire Super [DMI-triazole (3)/AP (9)]
Quilt-Xcel [DMI-triazole (3)/QoI (11)

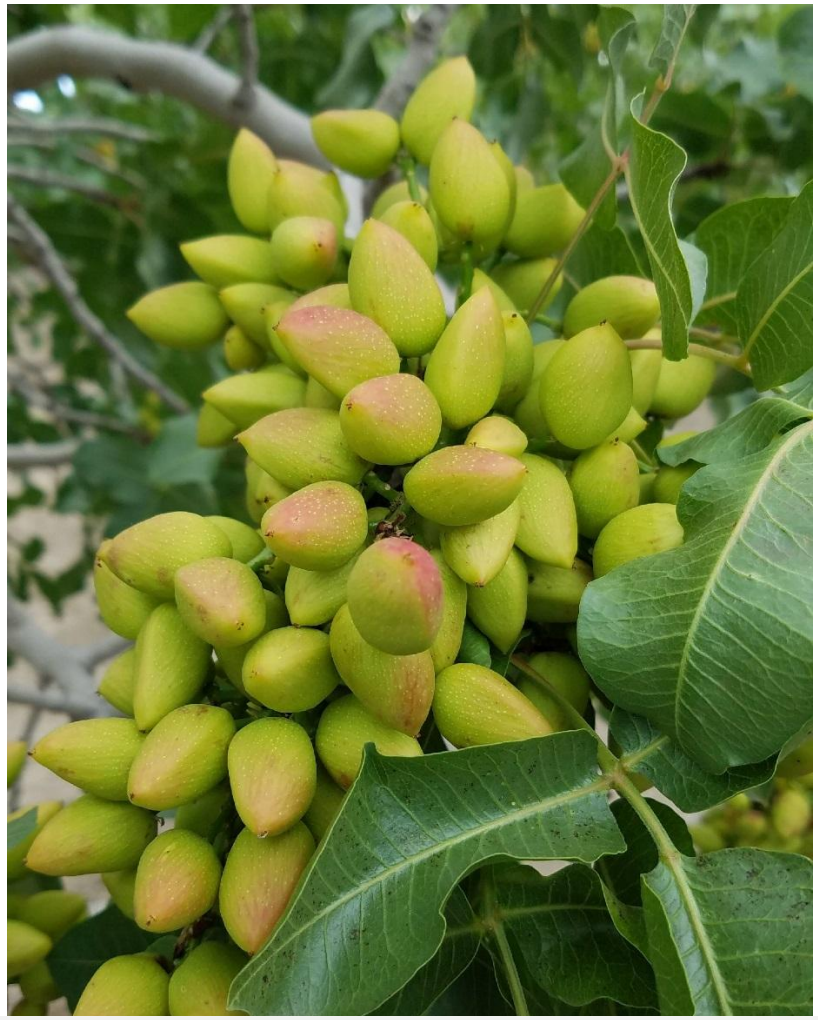
FUNGICIDE EFFICACY EXAMPLE

Timing of sprays

Apr 8, Jun 12*, Jul 10, Aug 6

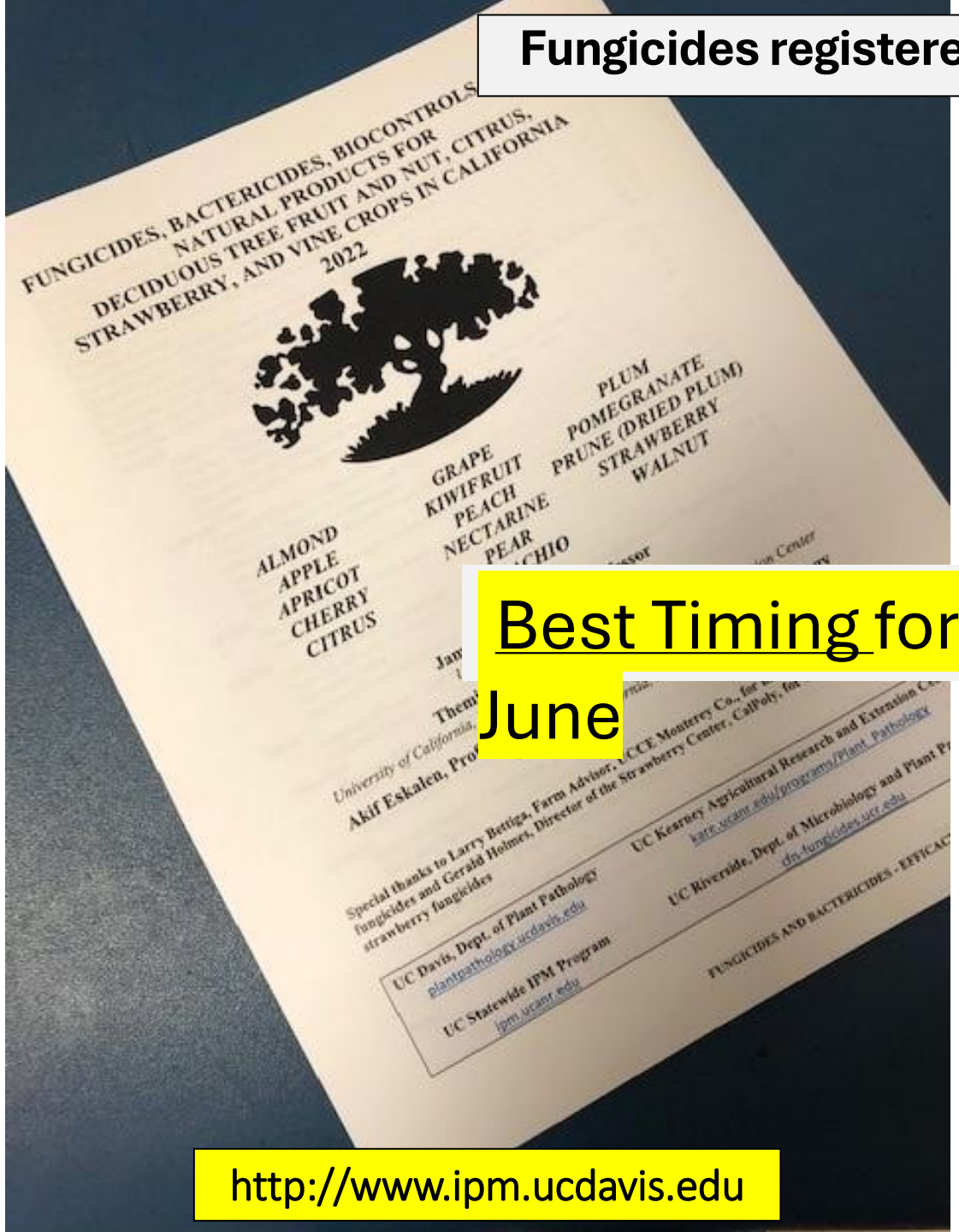


Biologicals are not effective against Bot panicle & shoot blight



Sprays
are done starting at bloom and finish by the end of July; spray(s) in August and/or later are not effective.

Fungicides registered for Bot panicle & shoot blight



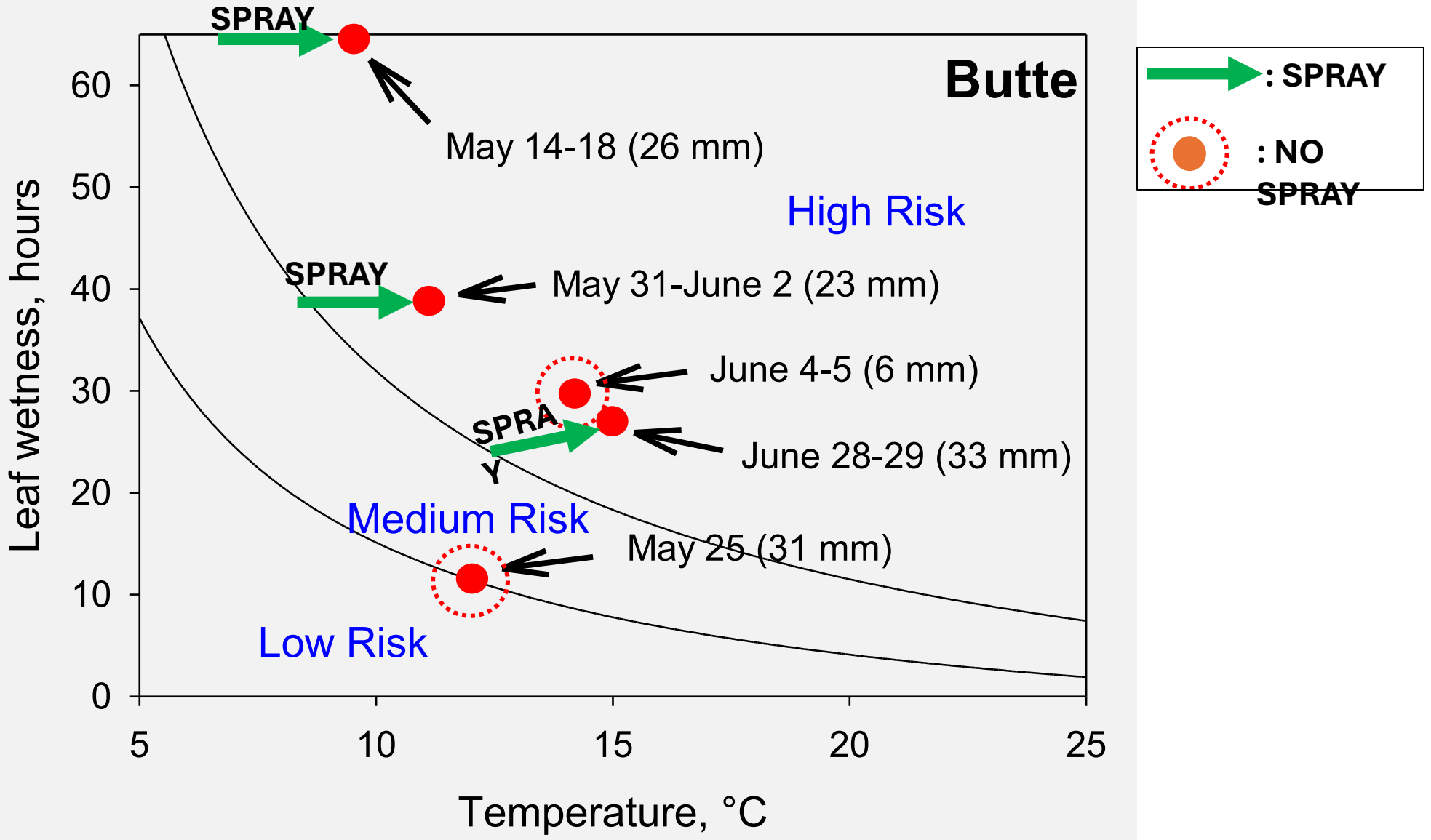
Best Timing for one spray: early June

http://www.ipm.ucdavis.edu

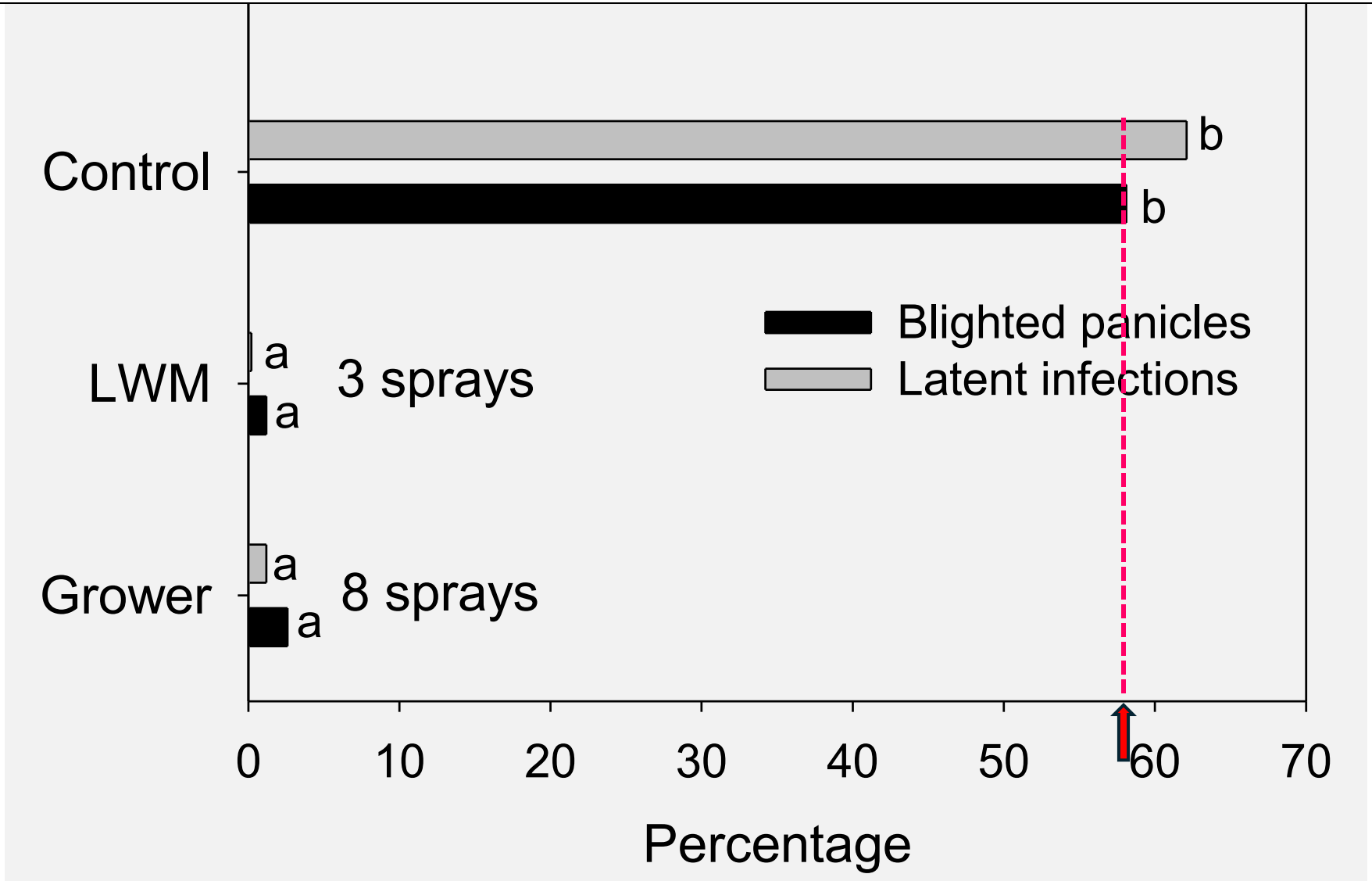
Fungicide	Active ingredient (FRAC)	Efficacy
Abound …….	azoxystrobin (11)	**4**
Caprio ……	pyraclostrobin (11)	**4**
Flint Extra……	trifloxystrobin (11)	**4**
Inspire Super….	difenoconazole + cyprodinil (3/9)	**4/5**
Quadris Top……	azoxystrobin+difenoconazole(3/11)	**4/5**
	yraclostrobin (7/11)	**5**
	clostrobin (7/11)	**5**
	Polyphosphite (33)	**4/5**
Luna Experience	fluopyram + tebuconazole (3/7)	**5**
Luna Sensation…	fluopyram + trifloxystrobin (7/11)	**5**
Cevya	mefentrifluconazole (3)	**5**
Miravis Duo	difenoconazole + pydiflumetofen (3/7)	**5**
Miravis Prime	pydiflumedofen + fludioxonil (7/12)	**5**
Quilt Xcel	propiconazole + azoxystrobin (3/11)	**4/5**
Adament	tebuconazole + azoxystrobin (3/11)	**4/5**
Fontelis	penthiopyrad (7)	**4/5**
Viathon	tebuconazole + phosphite (3/33)	**5**

5 = excellent & consistent; 4 = good & reliable

Leaf Wetness Model (LWM) in Butte County
(Medium- and high-risk infection events are sprayed)



Effect of fungicide sprays predicated by the LWM and compared with the grower's sprays against Bot panicle and shoot blight in Butte County, CA



Summary

1. Botryosphaeria panicle and shoot blight that started as a localized but devastating disease in northern CA became an epidemic 15 years later, following a few very wet years.

2. Some growers started cutting down trees (EMERGENCY), but those keeping their orchards or planting new pistachio orchards continued to have a big DILEMMA about any future success of this crop in CA.

3. The intensive and generous research funding by the California pistachio industry over the years resulted in a good understanding of the disease and the development of very effective cultural, chemical, and integrated management strategies.

4. And nowadays, pistachio growers are enjoying the fruits of their supported research with no worries for future disasters (SUCCESS!)

Following the Hurricane Hillary

…

Severe Alternaria late blight following the July rains in central valley - 2023

Botryosphaeria panicle and shoot blight - 2023

Anthracnose of pistachio in California

Themis Michailides & post-doc Paulo Lichtemberg

History of anthracnose in California:

Detected first in Tulare County in 1998.

No anthracnose was recorded from 1999 to 2016.

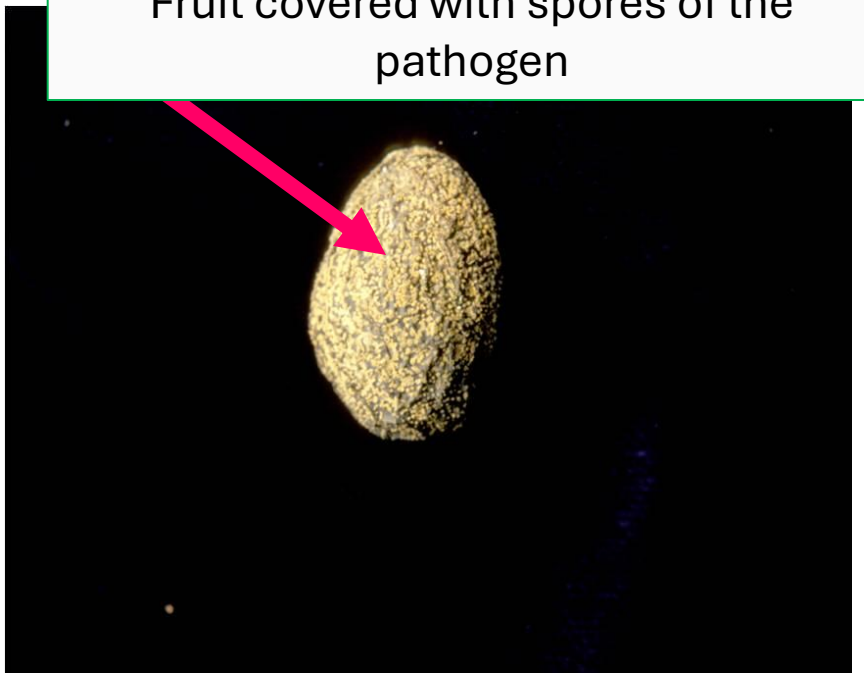
IN 2016, was found again in 2 orchards in northern California (Glenn Co) on Red Aleppo cv.
Red Aleppo was severely infected while the Kerman cv. Very lighly.
Both varieties were planted in the same field at 1:1 ration.
The disease was severe for a few years on Red Aleppo.
Grower cut this variety down, and the disease disappear.
No symptoms from 2000 to 2025.

(b) Anthracnose of pistachio

(b) Anthracnose of pistachio

Fruit covered with spores of the pathogen

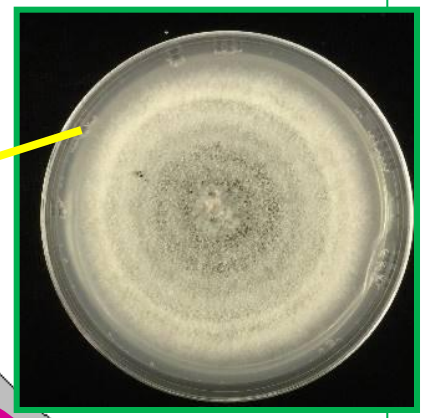
Colletotrichum acutatum

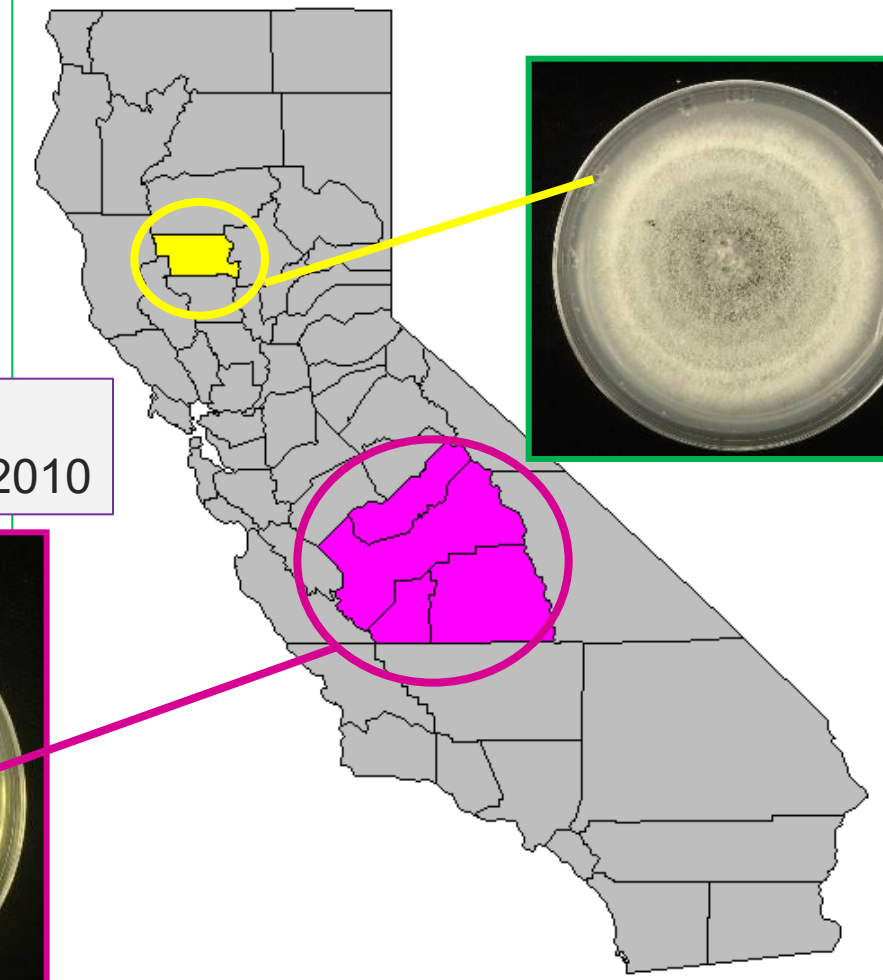


Anthracnose distribution

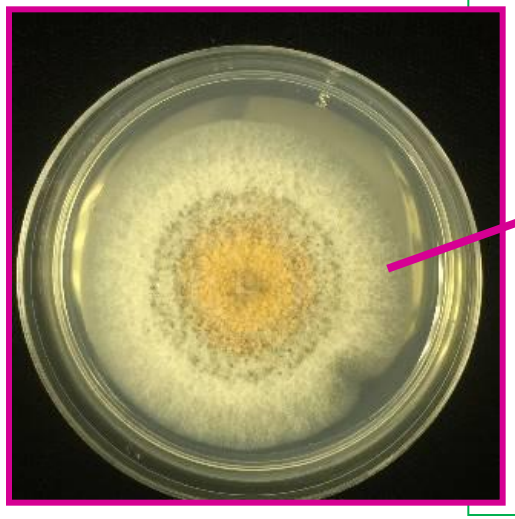
C. fioriniae
2016:2019

Kerman, Joley,
Red Aleppo

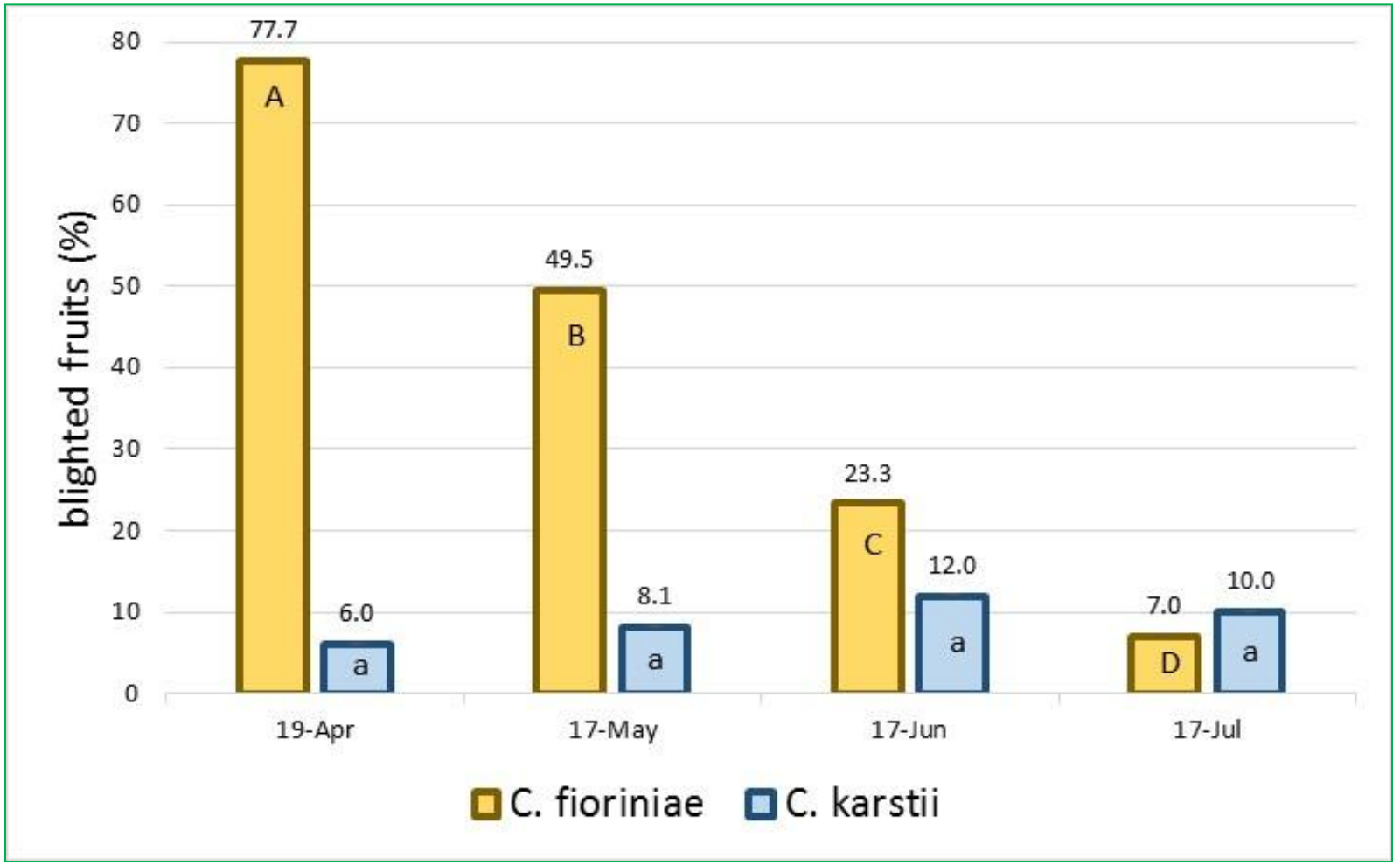




C. karstii
1998-2002 & 2004-2010

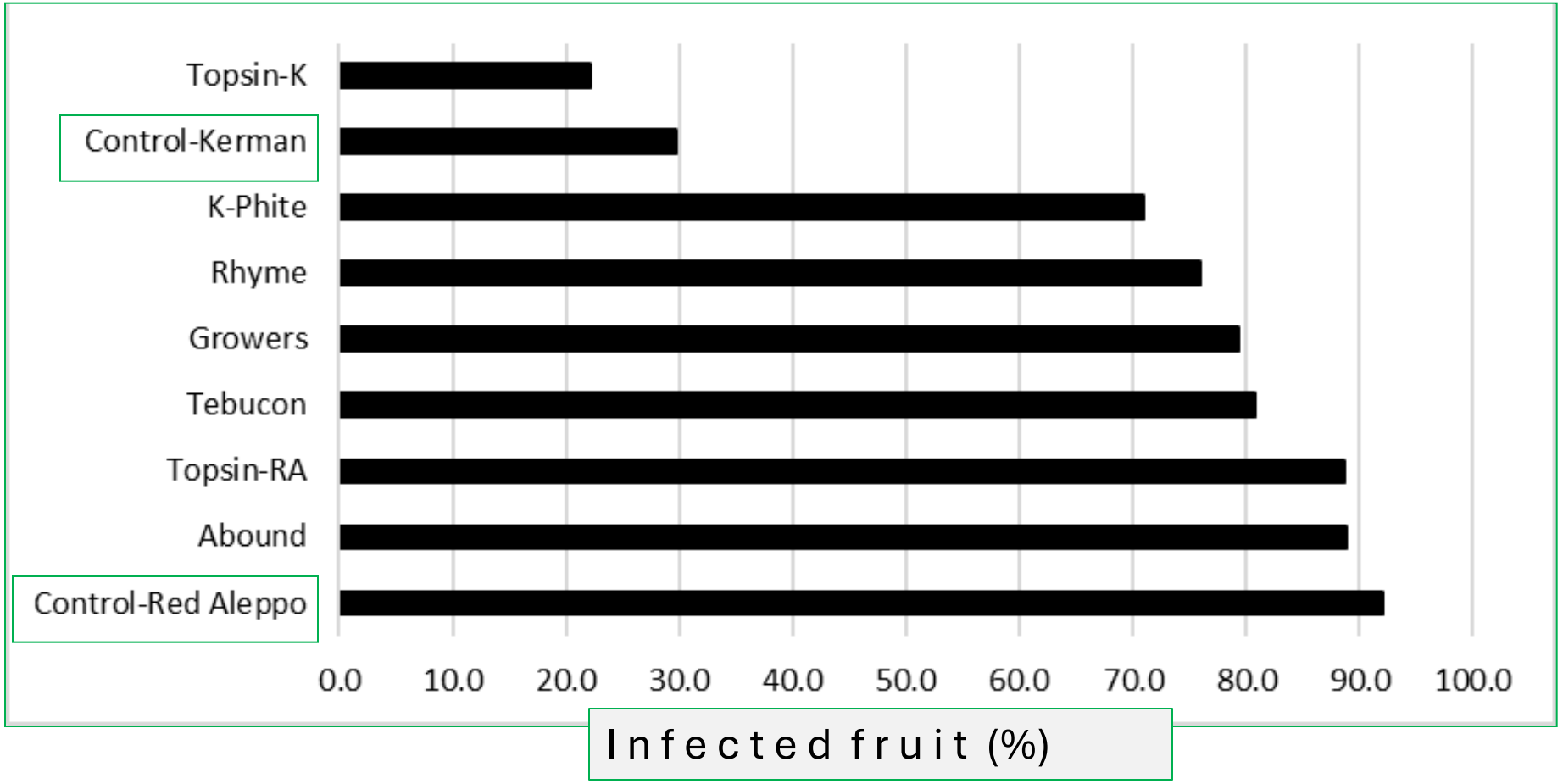


Susceptibility to *Colletotrichum* species



A 75% destruction of the crop in Australia (2010)

Control of anthracnose with fungicide sprays



Note: Kerman is very tolerant to disease, while Red Aleppo very susceptible. None of the fungicides worked (no statistical differences): We showed that almost all the isolates of *Colletotrichum* were resistant to these fungicides. (Topsin – K = Topsin on Kerman, not significant different vs. the untreated control)

THANKS....!

Blight of a pistachio cluster can also occur when large Hemiptera insects (*Leptoglossus* spp., leaffooted bug [LFB], *Chlorohoa* spp., etc.) puncture the fruit to feed and in this process inoculate the fruit with conidia. Infection will start from one or two fruits, grow through the peduncle, and move into the cluster rachis (main stem) to cause cluster blight.

The blighted rachis and the cankers play a significant role in the life cycle of the pathogen and the disease because portions of these tissues are covered with pycnidia of the pathogen, surviving on to the trees.

If a late season rain occurs and temperatures are still above 68°F, flower buds can get infected and become entirely or partially blighted, directly impacting next year's crop. Once the blighted shoots, clusters, and buds develop, it is too late to control the disease. However, protecting the green tissues from latent infections in the spring can control the disease. Sprays are done starting at bloom and finish by the end of July; spray(s) in August and/or later are not effective. If a grower has low pressure of the disease and desires to apply only one spray, the best timing would be the first part of June.